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AN EMPIRICALLY DERIVED CONTEXTUALIZED BLENDED INSTRUCTIONAL DELIVERY MODEL FOR DIGITAL LEARNING IN CAMEROON SECONDARY SCHOOLS

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Abstract

Digital learning has considerable potential to enhance teaching and learning, yet its effective implementation in Cameroonian secondary schools remains constrained by contextual challenges. This study aimed to design and propose a Contextualized Blended Instructional Delivery Model for Digital Learning in Cameroon secondary schools. The study used a convergent parallel mixed-methods approach, an empirical, primary research-based design. The study was guided by Constructivist Learning Theory, TPACK, the Technology Acceptance Model, Cost-Effectiveness Theory and the UNESCO ICT Competency Framework for Teachers. Data were gathered from 356 students, 108 teachers and 13 administrators in selected secondary schools of the Center, West and Littoral Regions using questionnaires and interviews. The findings pointed to constraints in terms of infrastructure, connectivity, electricity, teacher competence, institutional support and cost. Participants were however positive about digital learning, in particular mobile friendly, low data, offline resources, WhatsApp supported communication and blended instruction. The synthesis of findings informed the design of a model focusing on offline-first design, mobile access, low data usage, affordability, teacher support, and contextual adaptability. The study contributes an empirically grounded framework for sustainable digital learning in resource-constrained secondary school contexts.

Keywords:

Blended learning, digital learning, instructional delivery model, mixed methods, resource-constrained schools, contextualization, Cameroon

Résumé

L'apprentissage numérique présente un potentiel considérable pour améliorer les processus d'enseignement et d'apprentissage. Toutefois, sa mise en œuvre efficace dans les établissements secondaires camerounais demeure limitée par plusieurs contraintes contextuelles. Cette étude visait à concevoir et à proposer un modèle contextualisé de prestation pédagogique hybride pour l'apprentissage numérique dans les établissements secondaires au Cameroun. Elle a adopté une approche méthodologique mixte parallèle

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convergente, fondée sur une recherche empirique reposant sur des données primaires. L'étude s'est appuyée sur la théorie de l'apprentissage constructiviste, le cadre TPACK (Connaissances Technologiques, Pédagogiques et Disciplinaires), le modèle d'acceptation de la technologie, la théorie de la rentabilité économique ainsi que le Cadre de compétences des enseignants en matière de TIC de l'UNESCO. Les données ont été recueillies auprès de 356 élèves, 108 enseignants et 13 responsables administratifs dans des établissements secondaires sélectionnés dans les régions du Centre, de l'Ouest et du Littoral, au moyen de questionnaires et d'entretiens. Les résultats ont révélé plusieurs contraintes liées aux infrastructures, à la connectivité, à l'approvisionnement en électricité, aux compétences des enseignants, au soutien institutionnel et aux coûts. Toutefois, les participants ont exprimé des attitudes favorables à l'égard de l'apprentissage numérique, notamment en ce qui concerne les ressources accessibles sur les appareils mobiles, nécessitant peu de données Internet, disponibles hors ligne, la communication soutenue par WhatsApp et l'enseignement hybride. La synthèse des résultats a permis d'élaborer un modèle axé sur une conception privilégiant l'accès hors ligne, l'accessibilité mobile, la faible consommation de données, l'abordabilité, l'accompagnement des enseignants et l'adaptabilité aux réalités contextuelles. Cette étude contribue ainsi à la proposition d'un cadre conceptuel fondé sur des données empiriques, en faveur d'un apprentissage numérique durable dans les établissements secondaires évoluant dans des contextes caractérisés par des ressources limitées.

Mots-clés: *apprentissage hybride, apprentissage numérique, modèle de prestation pédagogique, méthodes mixtes, établissements scolaires à ressources limitées, contextualisation, Cameroun.*

Introduction

Digital technology has increasingly been woven into education, offering pathways to expand access to learning resources, enhance communication and collaboration, diversify instructional representations, and support assessment and feedback. Technology alone, however, is not sufficient to effect any meaningful change in education. Its contribution is dependent on the interaction between infrastructure, teacher competency, pedagogical practices, learner access, institutional support, cost and the context within which it is introduced. The Global Education Monitoring Report (2023) of UNESCO thus emphasizes that technology must be used for educational purposes, relevant to the national and local context, rather than being considered an inherently good intervention. This is particularly critical in resource constrained educational environments.

Problem Statement

Digital-learning models are often developed around assumptions of stable electricity, reliable internet connectivity, adequate devices, technically competent teachers, and institutional capacity to maintain technological systems. These assumptions may not hold in many schools in low- and middle-income settings. Where connectivity is intermittent, electricity is unstable, devices are shared, and technical support is limited, an instructional model that depends heavily on continuous online access may be difficult to implement even where schools formally possess digital infrastructure. Cameroon provides an important context for examining this challenge. The evolution of ICT in education has been recorded with ongoing issues around infrastructure, access, teacher

competence, maintenance and pedagogical integration (Béché, 2017; Djeumeni-Tchamabe, 2010; Fonkoua, 2009; Nganji et al., 2010; Ngoungouo, 2017). Recent studies also consolidate difficulties related to digital appropriation, teachers' mastery, access to e-learning, acceptance of e-learning and technopedagogical competence (Giresse & Djeumeni, 2025; Mvogo et al., 2026; Nana & Banen, 2024).

These studies have generated important evidence, but the literature remains fragmented across individual dimensions of digitalization. Some studies emphasize infrastructure, others teacher competence, ICT use, professional development, e-learning acceptance, or digital platforms. What remains insufficiently addressed is how these interconnected conditions can be systematically integrated and translated into a contextually appropriate instructional delivery model for secondary schools operating under resource constraints. The present study addresses this evidence-to-design gap. Rather than beginning with a predetermined technology package and asking how schools can adopt it, the study begins with empirical evidence concerning infrastructure functionality, teacher competence, learner access, institutional conditions, cost pressures, and stakeholder preferences. The evidence is then integrated to identify design requirements and translate them into a proposed Contextualized Blended Instructional Delivery Model. The central conceptual proposition is that digital-learning design in resource-constrained educational environments should move beyond the question of whether technology is available to consider whether it is functional, instructionally usable, affordable, sustainable, and realistically accessible to teachers and learners.

Research Questions

The study was guided by two research questions:

1. What contextual conditions shape the feasibility of blended digital learning in Cameroon secondary schools?
2. What design requirements emerge from the integrated quantitative and qualitative findings for the development of a Contextualized Blended Instructional Delivery Model for Digital Learning in Cameroon secondary schools?

The study contributes to the literature by demonstrating a process through which multi-stakeholder empirical evidence can be translated into a context-responsive instructional model. Its central contribution is therefore not the promotion of a particular technology, but an evidence-based design logic in which context, infrastructure functionality, instructional usability, teacher competence, learner access, cost, pedagogy, and institutional support are treated as interdependent conditions of digital learning.

LITERATURE REVIEW

From Technology Availability to Instructional Usability

A critical distinction in this study is between availability of technology, functionality, instructional usability and actual implementation. Having the digital infrastructure available does not mean that it will be used meaningfully in the classroom. The success of technology integration is not only dependent on the infrastructure but also on the relationship among infrastructure, teacher readiness, pedagogical knowledge, technical

support and the context's conditions (Hawkins et al., 2020; Koehler & Mishra, 2009; UNESCO, 2023). Schools may have computer labs, projectors, internet subscriptions or digital platforms but these are underutilized due to equipment failure, unreliable electricity, lack of connectivity, high costs, poor maintenance or teacher competence (Hawkins et al., 2020; UNESCO, 2023). Other studies on technology integration have shown that access to digital resources is not sufficient for the teachers to appropriately choose, adapt and integrate digital resources into instruction but they need to have technological and pedagogical knowledge for that (Koehler & Mishra, 2009; Tondeur et al., 2017). Thus, the present research views digital-learning implementation as a process of availability → functionality → instructional usability → implementation. This evolution is based on the recognition that educational technology is an integrated system of infrastructure, teachers, learning resources, pedagogy and institutional support, rather than a series of discrete technological inputs (Hawkins et al., 2020; UNESCO, 2023). Consequently, technology inventories that measure only the presence of devices or facilities may overestimate schools' actual digital readiness. Building on these perspectives, the present study treats functionality and instructional usability as explicit design conditions, thereby distinguishing technological provision from the capacity to translate available resources into sustained instructional practice.

Contextualization

Contextualization means consciously adapting the processes of teaching, the technological tools, the pedagogical approaches and the support systems to the context in which the teaching and learning take place. This convergence is especially relevant when considering Cameroonian secondary schools where the effective integration of digital technologies depends on the interaction of constraints related to infrastructure, access, teachers, institutions and pedagogy (Nana & Banen, 2024; Tchameni Ngamo & Karsenti, 2008). Current evidence suggests that these constraints are not independent barriers but interact to influence the appropriation of available technologies for meaningful use in instruction. For example, Nana and Banen (2024) argue that teachers' access to and capacity to master electronic tools is a barrier to converting technological resources into classroom practices, and that the provision of technology alone does not guaranty its use.

According to Mvogo et al. (2026), the acceptance and adoption of e-learning by teachers are facilitated by the existence of technological and pedagogical knowledge, enabling conditions, and institutional infrastructure. To summarize, the studies indicate that the success of digital learning depends on the synchronization between the existing technology, the teachers' ability to use it and the institutional context that allows its use. The pedagogical design and organization of digital learning environments influence the quality of technology integration in Cameroonian secondary schools (Giresse & Djeumeni Tchamabe, 2025). This alignment should also be reflected in the design of learning experiences. Building on this evidence, contextualisation in the present study encompasses infrastructure functionality, electricity availability, internet connectivity, device access, teacher competence, learner readiness, cost, institutional support, class conditions, and pedagogical requirements. These dimensions' position contextualisation not merely as adaptation to technological limitations but as a systemic design requirement through which digital-learning strategies are aligned with the material,

technological, economic, pedagogical, and institutional realities of Cameroon secondary schools. Consequently, rather than transferring models developed in better-resourced educational settings, the present study proposes that digital-learning delivery should be designed from the conditions, capacities, and needs of the schools and users in which implementation is expected to occur.

Theoretical Backgrounds

The proposed model is developed based on five complementary theoretical perspectives that address the pedagogical, technological, behavioural, economic and professional dimensions of digital-learning implementation. The pedagogical base is grounded in Constructivist Learning Theory, which advocates for active learning, interaction, collaboration, experience and reflection (Piaget, 1973; Vygotsky, 1978). TPACK argues that technology integration is effective if there is an interaction between technological, pedagogical, and content knowledge (Mishra & Koehler, 2006). TAM explains the technology acceptance with perceived usefulness and ease of use (Davis, 1989). The theory of cost-effectiveness studies the relationship between the benefits of education and the resources needed to achieve them, so that one can be able to introduce education in practice and sustain it (Levin & McEwan, 2001). The UNESCO ICT Competency Framework for Teachers emphasizes the progressive development of basic ICT skills to the more sophisticated pedagogical integration (UNESCO, 2018). These perspectives contribute to learner engagement, teacher knowledge, technology acceptance, resource sustainability, and professional development. They provide a comprehensive theoretical basis for a contextualized, viable and teacher-supported blended instructional delivery model for secondary schools.

Materials and Methods

The study employed an empirical, primary research-based convergent parallel mixed-methods design, in which quantitative and qualitative data were collected concurrently, analysed independently, and integrated during interpretation to generate evidence-based model requirements. The study involved 356 students, 108 teachers, and 13 administrators from selected secondary schools in Cameroon's Centre, West, and Littoral Regions. Multi-stage sampling was used, combining purposive, stratified, random, consecutive, and purposive procedures for the respective participant groups. Data were collected using structured student and teacher questionnaires and semi-structured administrator interviews. Quantitative data were analysed using frequencies, percentages, means, and standard deviations, while qualitative data were analysed thematically following Braun and Clarke's (2006) six-phase approach. Findings were integrated through triangulation and joint interpretation to identify context-specific evidence informing the model development.

Results and Discussion

This section presents a comprehensive descriptive analysis of quantitative data and the thematic content analysis of qualitative data gathered from the field. These results were presented following the research the questions stated above. The quantitative and qualitative result were presented separately and then integrated following triangulation

to identify convergent, complementary, and context-specific evidence informing model development

Question 1: What contextual conditions shape the feasibility of blended digital learning in Cameroon secondary schools?

Table 1 Teacher Digital Competence

Statement	NR	Mean	SD
My skills in basic computer operations is	108	2.30	1.41
My skill in using word processing software is	108	2.32	0.81
My skill in using presentation software for lesson is	108	2.84	1.27
My skills in using spreadsheet software is	108	2.39	1.00
My ability to use internet for research is	108	2.59	1.09
My ability to use email for communication is	108	2.58	0.83
My ability to use learning management system (LMS) is	108	2.84	1.10
My ability to create digital learning content is	108	2.11	0.92
My skill to troubleshoot basic technical issues is	108	2.21	0.92
Total		2.47	1.04

The results indicate that teachers' digital competence is low to moderate with a mean of M = 2.47 (SD = 1.04). The competence of using presentation software and LMS was relatively higher (M = 2.84 each) but significantly lower in digital content creation (M = 2.11), troubleshooting (M = 2.21), and basic computer operations (M = 2.30). This pattern highlights the need for embedded teacher training, technical support, and simplified instructional technologies within the proposed model.

Table 2 Access and Readiness Indicators

Statement	yes		No	
	Frequency	Percentage	Frequency	Percentage
I have a smart phone	208	58.4	149	41.6
I have a laptop/ tablet	98	27.5	258	72.5
I have access to a computer in school	265	74.4	91	25.6
I have access to internet at home	278	78.1	78	21.9
I have access to internet in school	22	6.2	334	93.8
I use mobile data for learning	272	76.4	84	23.6
I don't have access to internet at all	76	21.3	280	78.7
I don't have access to any digital devices	74	20.3	282	79.2

From Table 2 above the findings show that students vary in their digital access and readiness. 58.4% had smartphone ownership, 74.4% had access to school computers but only 27.5% had a laptop or tablet. Internet access at home was quite high (78.1%) but access to the internet at school was very limited (6.2%). And 76.4 per cent relied on mobile data to learn. These findings underscore the need for a mobile-first, low-data, and offline-capable instructional model that accommodates substantial variation in students' digital access.

Table 3 Teachers proposed components essential to design the instructional model

Model components	Very important f(%)	Important f(%)	Not important f(%)
Access to Offline learning materials	51 (47.2)	36 (33.3)	21 (19.4)
Use of communication apps to communicate with students such as WhatsApp	44 (40.7)	46 (42.6)	18 (16.7)
The integration learning management system such as google classroom	20 (18.5)	58 (53.7)	30 (27.8)
The use of mobile-friendly platforms	36 (33.3)	64 (59.3)	8 (7.4)
Low data consumption digital systems	36 (33.3)	55 (50.9)	17 (15.7)
Pre-download videos lessons that are not heavy.	38 (35.2)	53 (49.1)	17 (15.7)
Interactive quizzes and assessment platforms.	29 (26.9)	58 (53.7)	21 (19.4)
Teacher facilitation guides and technical support.	36 (33.3)	54 (50.0)	18 (16.7)
Learner collaboration platforms	47 (43.5)	43 (39.3)	18 (16.7)
Structured lesson phases (introduction, activity, feedback)	32 (29.6)	59 (54.6)	17 (15.7)

From table 3 above, the results suggest that teachers strongly support the components of the proposed model. The combined importance rating was highest for mobile-friendly platforms (92.6%), followed by low-data systems (84.2%), video lessons that could be downloaded in advance (84.3%) and teacher facilitation and technical support (83.3%). There was also strong support for offline materials (80.5%) and WhatsApp communication (83.3%). Overall, the results emphasize accessibility, low data requirements, offline functionality, mobile compatibility, and teacher support as central design requirements for the instructional model.

Table 4 teachers' view on cost effectiveness on digital learning in their institution

Statement	NR	Mean	STD
Digital learning is really costly to the school to effectively implement it	108	3.11	1.715
The cost of internet data is actually a major barrier to digital learning in my school.	108	3.15	1.600
The maintenance of digital devices is very costly for my school.	108	3.51	1.167
The provision of electricity to the whole school is really expensive to the administration.	108	3.35	1.130
Our school budget cannot effectively sustained digital learning on our campuses.	108	3.57	1.174
Total		**3.34**	**1.36**

Results suggest moderate to high perceptions of cost-related barriers to digital learning (overall M = 3.34, SD = 1.36). The most important ones were budgetary limitations (M=3.57), maintenance of devices (M=3.51) and electricity costs (M=3.35). The cost of Internet data was also noted as a major obstacle (M = 3.15), implying that continuous operational costs may limit sustainable use of digital learning.

Table 5 Final Themes, Subthemes and Evidence

Theme	Subthemes	Principal qualitative evidence
1. Digital Learning Infrastructure	Functionality; electricity; internet; maintenance; class size	Unstable electricity, weak connectivity, insufficient devices, maintenance deficits
2. Institutional Readiness and Support	Readiness; teacher support; leadership	Wide variation in readiness and support
3. Teacher Capacity and Instructional Practices	Competence; content creation; monitoring	Uneven digital competence and limited pedagogical integration
4. Cost-Effectiveness and Sustainability	Cost drivers; recurring costs; sustainability	Electricity, maintenance, connectivity and training costs
5. Policy Alignment and External Support	Policy guidance; external support; policy-practice gap	Policy expectations frequently exceed school capacity
6. Administrators' Recommendations for Model Design	Feasibility; conditions; easy/difficult components; adoption	Offline/WhatsApp components more feasible; internet/computer components more difficult

From table 5, the Qualitative findings generated six interrelated themes that informed the proposed model. The digital learning infrastructure was hampered by unreliable

electricity, poor connectivity, lack of devices and maintenance problems. Schools varied in terms of their institutional readiness and support and the level of leadership, preparedness and teacher support they were able to provide. Uneven digital competence and limited pedagogical integration were described as teacher capacity and instructional practices. The recurring costs of electricity, connectivity, maintenance and training meant it was not cost-effective and sustainable. Policy coherence and external support revealed gaps between policy expectations and capacity at school level. Finally, offline and WhatsApp-based components were found more feasible by administrators, while internet-dependent and computer-intensive components were more difficult to implement.

Integrated Findings and Design Requirements

Question 2: What design requirements emerge from the integrated quantitative and qualitative findings for the development of a Contextualized Blended Instructional Delivery Model for Digital Learning in Cameroon secondary schools?
The integrated evidence generated five principal design requirements.

Table 6 Integrated Quantitative–Qualitative Findings and Emerging Model Design Requirements

Research evidence	Quantitative finding	Qualitative finding	Integrated interpretation	Design requirement
Infrastructure functionality	Only 38.0% of laboratories functional	Administrators reported insufficient and broken equipment	Infrastructure presence does not guarantee usability	Low-resource resilience
Internet access	66.6% reported no internet during lessons	Administrators described internet as slow, expensive, unreliable, or absent	Continuous connectivity cannot be assumed	Offline-first
Mobile access	58.4% of students had smartphone access	Administrators viewed WhatsApp as relatively easy	Mobile devices provide a practical communication pathway	Mobile-first
Teacher competence	Digital competence generally limited	Administrators reported uneven competence and limited content creation	Teacher capacity constrains technology integration	Embedded teacher support

Costs	Teachers reported substantial personal digital expenses	Administrators identified electricity, maintenance and internet as major recurring costs	Sustainability requires reduction of recurrent costs	Cost-conscious design
Policy-practice gap	Implementation challenges reported by teachers	84.6% of administrators described substantial policy-practice gaps	Policy expectations must be translated into feasible school-level procedures	Contextual implementation

The integrated findings indicate that the design of digital-learning implementation in Cameroonian secondary schools must be contextual, flexible and resilient. Infrastructure functionality is limited and connectivity unreliable, so an offline-first approach is needed. Smartphones do allow for mobile first communication. But not non-mobile alternatives. Where teachers have uneven skills, technical and pedagogical support needs to be embedded, and large ongoing costs require a cost-conscious choice of resources. The policy-practice gap also suggests the need for feasible implementation pathways at the school level rather than blanket requirements. Taken together, these findings point to five core requirements: offline-first design; mobile-first access; resilience to low-resource environments; cost-conscious design; and embedded teacher support, with flexible implementation pathways and blended rather than fully online delivery.

From Empirical Findings to the Proposed Model

The development process can be summarized as follows:

Empirical Evidence → Integrated Findings → Contextual Problems → Design Requirements → Model Components → Instructional Processes → Expected Outcomes → Monitoring and Refinement

This evidence-to-design sequence constitutes the core methodological contribution of the study.

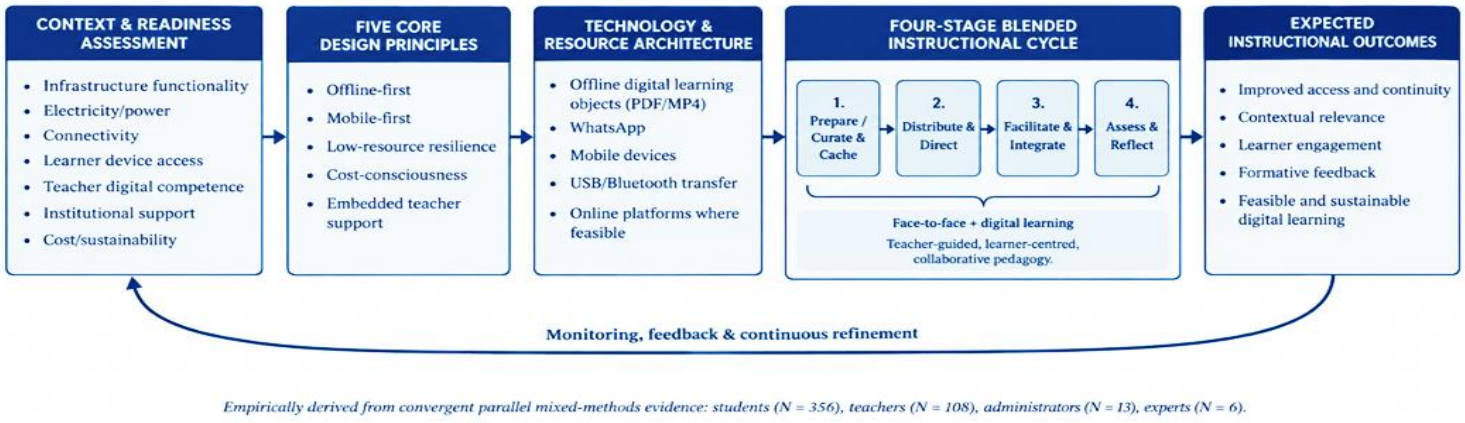
Model Architecture

The proposed model consists of five interconnected layers:

1. Context and readiness assessment
2. Core design principles
3. Technology and resource architecture
4. Blended instructional delivery cycle
5. Monitoring, feedback, and refinement

Figure 1

Contextualized Blended Instructional Delivery Model for Digital Learning in Cameroon Secondary Schools



Note. DLOs = digital learning objects.

Context and Readiness Assessment

The model begins with a contextual readiness assessment rather than immediate technology adoption, recognizing that effective digital learning depends on the interaction between technological, institutional, and pedagogical conditions. Accordingly, schools assess the functionality of existing devices, electricity reliability, connectivity, data affordability, student device access, teacher competence, technical support, institutional leadership, class size, recurrent costs, and pedagogical requirements. These dimensions are considered interdependently because weaknesses in one area may constrain the usefulness of strengths in another. Thus, readiness is not treated as a binary condition of being "ready" or "unready"; rather, the assessment determines how the model should be configured to reflect each school's actual resources, constraints, and instructional priorities.

Offline-First Design

Offline-first design places resources that remain usable without continuous internet connectivity at the centre of instructional delivery, thereby responding directly to environments where connectivity is intermittent, costly, or unavailable. Rather than treating offline access as a temporary substitute for online learning, the model integrates it as a deliberate design principle through compressed videos, PDF documents, audio resources, presentations, images, locally stored quizzes, and curriculum-aligned interactive materials. Teachers can therefore download or prepare resources when connectivity is available and subsequently use them during face-to-face instruction. Other distribution methods such as USB drives, Bluetooth, memory cards, device-to-device transfer and mobile messaging further reduce dependence on persistent internet access while maintaining instructional continuity.

Mobile-First but Not Mobile-Only

The model recognizes smartphones as an important access path, but sees mobile-first design as an enhancement of access, not a mobile-only strategy. Resources, therefore, should be lightweight, readable on small screens, inexpensive to access and easy to navigate, while WhatsApp can facilitate communication, distribution of resources, reminders, discussion prompts and feedback as appropriate. However, the 41.6% of students who did not report owning a smartphone point to the need of complementary access mechanisms. These include shared devices, school computers, paired/group activities, USB/Bluetooth distribution, and teacher-led classroom activities and printed alternatives. Such flexibility enables the model to accommodate heterogeneous patterns of device access without excluding less-connected learners.

Low-Resource Resilience

Low-resource resilience is the idea that instructional goals can still be achieved even if some of the technologies do not work, moving the model from technology dependence to instructional continuity. This principle states that each digital activity must have a reasonable alternative that serves the same underlying learning purpose. So an online discussion can be a classroom group discussion, an online quiz can be an offline quiz and an online video can be replaced by a copy saved on your computer. Similarly, digital assignments can be adapted to classroom activities and online resources cached for future use. Such flexibility makes technological failure a manageable implementation constraint rather than a barrier to achieving intended learning outcomes.

Cost-Consciousness

Financial sustainability is a factor for the longevity of digital learning, making the model sensitive to capital outlays and running costs. This way the model supports free or low-cost tools, reusable resources, compressed files, offline distribution, shared devices, existing infrastructure, locally developed materials and reduced reliance on continuous mobile data. These strategies are designed to reduce preventable expenditure and optimize the use of existing resources within schools and communities. But be careful not to confuse cost-conscious design with proven cost effectiveness. Rather, it represents a deliberate design principle through which economic sustainability is incorporated into implementation decisions, while empirical cost-effectiveness remains subject to future evaluation.

Embedded Teacher Support

Teacher support is integrated throughout the model because sustainable digital learning depends not only on access to technology but also on teachers' capacity to use it pedagogically. Professional development therefore encompasses basic digital operations, digital-content development, resource curation, lesson planning, digital assessment, formative feedback, collaborative digital pedagogy, troubleshooting, and reflective practice. This broad focus links technical competence to instructional decision making and goes beyond skills specific to technology. In this regard, the model echoes UNESCO's emphasis on preparing teachers to effectively integrate technology into teaching and

learning, rather than restricting professional development to the use of specific digital resources.

Four-Stage Instructional Cycle

Stage 1: Prepare / Curate and Cache: Teachers identify learning objectives, select or develop appropriate resources, check their accessibility and relevance, and download or cache materials when possible.

Stage 2: Distribute and Direct: Resources are distributed through the most appropriate channel: WhatsApp, USB, Bluetooth, school computers, local storage, or online platforms. The teacher provides clear instructions concerning what learners should read, watch, practise, discuss, or prepare.

Stage 3: Facilitate and Integrate: Digital resources are embedded within the teacher-led interaction of the classroom, not in place of instruction. Teachers help students to solve problems, correct misunderstandings and learn together. They look at digital content, group students and make connections to local examples and resources. This approach, by establishing technology as a pedagogical resource, reinforces and not replaces teacher mediation.

Stage 4: Assess and Reflect: Teachers assess learning through quizzes, questions, assignments, collaborative tasks, discussion, and other formative activities. They then reflect on:

1. whether learners accessed the resource;
2. whether the technology functioned;
3. whether the resource supported the learning objective; and
4. what should be modified for the next cycle.

Flexible Implementation Pathways

The model provides three broad pathways.

Basic/Low-Resource Pathway: Offline digital resources + face-to-face teaching + shared devices + USB/Bluetooth + printed alternatives.

Mobile-Supported Pathway: Offline resources + smartphones + WhatsApp + mobile-friendly videos/PDFs + mobile assessment and feedback.

Connected Blended Pathway: Online platforms + learning-management systems + internet-based research + online assessment + face-to-face instruction.

These pathways are not rigid stages. Schools may select or combine them according to their contextual readiness.

Discussion

The results show that the major problem of digital learning in Cameroonian secondary schools is not the availability of technology, but the congruence of technological resources, instructional conditions and the ability to sustain classroom use. The large

discrepancy between reported computer-laboratory availability (98.1%) and functional availability (38.0%) suggests that infrastructure should be thought of in terms of usability and instructional functionality, not physical presence. This view is consistent with Farinkia and Tambi (2018), who noticed insufficient facilities for ICT in Cameroonian public secondary schools, especially in less-resourced environments. Thus, the proposed model treats electricity, connectivity, technical support, teacher competence, and pedagogical usability as interconnected conditions of readiness.

Results further confirm the importance of contextualization as a core design principle. Schools do not have equal connectivity, devices, electricity or technical support, so a model that requires constant internet access would replicate the inequalities that exist. Nana and Banen (2024) similarly found that limited access, insufficient mastery, and weak use of digital technologies constrain teachers' pedagogical practices in Yaoundé. The present findings therefore justify an offline-first and mobile-first approach, while retaining non-mobile alternatives such as shared devices, school computers, Bluetooth, USB distribution, and teacher-mediated activities. Mobile-first should consequently be understood as an access strategy, not a mobile-only requirement.

Teacher capacity is equally central because technology cannot independently convert resources into learning. The low level of teacher digital competence found in this study means that the model needs to incorporate professional development, content curation, digital lesson planning, assessment, feedback, and troubleshooting. These findings support the UNESCO (2018, 2023) claim that technology integration is a function of teacher preparedness, contextual fit and human interaction. Finally, the reported personal expenditure on devices, data, and electricity indicates that sustainability requires attention to recurrent costs. The proposed blended model therefore combines face-to-face teaching with offline and low-data digital resources, allowing technology to extend communication, practice, assessment, and feedback without making continuous connectivity a prerequisite for participation. The approach gives priority to continuity, equity, feasibility and sustainability.

Implications and Limitations

Practical Implications: Schools should start their digital educational journey by assessing readiness in their context including functional devices, connectivity, reliability of electricity, teacher support needs, learner access and sustainable recurrent costs. Teacher development should then proceed progressively, combining technical competence with digital pedagogy, content development, assessment, troubleshooting, and reflective practice rather than relying on one-off workshops.

Policy Implications: For policymakers, digital-learning investment should extend beyond equipment provision to include maintenance, reliable electricity, technical assistance, teacher professional development, appropriate digital content, functionality monitoring, and sustainable recurrent funding. Infrastructure targets should therefore distinguish between equipment supplied and equipment that remains operational, since availability alone may substantially overstate actual instructional capacity.

Equity Implications: The model has an explicit equity orientation. Mobile-first design increases access for learners who can use smartphones, while the mobile-only approach is avoided because not all learners possess smartphones. Offline resources reduce dependence on continuous connectivity, while alternative pathways protect learners when devices or networks are unavailable. The model therefore treats flexibility as an equity mechanism rather than simply an implementation convenience.

Conclusion

Digital learning in secondary schools with limited resources requires designs that respond to contextual realities rather than assumptions of universal technological access. This research's findings revealed a distinct difference between availability, functionality, instructional usability, and implementation of infrastructure. Computer labs were everyplace, but their capabilities were limited and the access to devices and the connectivity among students was heterogeneous. Teachers saw the benefit of digital technologies but the use was limited by differences in digital skills and the support they received from their institutions. The proposed Contextualized Blended Instructional Delivery Model responds with five principles: offline-first design, mobile-first design, low-resource resilience, cost-consciousness, and embedded teacher support. These principles are implemented through a four-stage cycle: Prepare/Curate and Cache, Distribute and Direct, Facilitate and Integrate, and Assess and Reflect. The model provides an evidence-to-design framework that links context, readiness, appropriate technology, teacher capacity, blended pedagogy, assessment, feedback and refinement. Its implementation effectiveness, scalability, and sustainability remain subjects for future empirical evaluation across Cameroonian secondary school settings over time.

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Compliance with ethical standards

Disclosure of conflict of interest
No conflict of interest to be disclosed.
Statement of informed consent
Informed consent was obtained from all individual participants included in the study.

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