Indonesian Journal of Educational Research and Technology

Bridging Educational Gaps: Integrating ICT into Timor-Leste's 2014 Primary Curriculum for Inclusive Digital Learning

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A B S T R A C T

This systematic review investigates the integration of Information and Communication Technology (ICT) into Timor-Leste's 2014 primary school curriculum and examines its transformative potential and implementation challenges. ICT aims to modernize education, enhance student engagement, and address inequalities in access and quality, particularly in rural and underserved communities. The review applied PRISMA guidelines and analyzed academic and institutional sources published between 2016 and 2024. Findings show that ICT improves student learning outcomes, fosters critical thinking, and enables personalized, inclusive learning. However, challenges include limited infrastructure, insufficient teacher training, and digital access disparities, especially for girls and low-income students. The study underscores the need for strategic interventions, including teacher capacity-building, infrastructure development, and gender-sensitive policies. It recommends localized digital content and inclusive digital literacy programs to ensure equitable access. These efforts align with Sustainable Development Goal 4 (Quality Education) by promoting digital equity and resilience in Timor-Leste's education system.

A R T I C L E   I N F O

1. INTRODUCTION

The 2014 primary school curriculum in Timor-Leste uses information and communications technology (ICT) as a strategic tool that brings essential modernisation to education while enhancing learning performance. Rapid technological development brings along an innovative power for ICT that creates new teaching techniques and enhances student connection to learning while opening education resources to more learners. The government of Timor-Leste follows global education trends by modifying its curriculum to teach digital literacy and twenty-first-century abilities. Thorough framework development remains essential for achieving ICT implementation success, since it must maximise advantages while solving implementation challenges. Research from global educational projects, including the Australian Government's Basic Education Quality and Access in Lao PDR, demonstrates that purposeful ICT financing strengthens classroom effectiveness (Shymansky *et al.*, 2013). The adoption of ICT in education demands strategic data management along with policy planning that leads to sustainable implementation (Bolaji & Jolaoye, 2022).

The 2014 Primary School Curriculum in Timor-Leste promotes both scholarly performance and 21st-century professional abilities and competencies. The present curriculum incorporates ICT as a fundamental component to give students innovative platforms that strengthen their ability to analyse situations and create solutions, along with their digital literacy skills. Educational technology enables teachers to solve long-standing educational problems that affect students in remote locations who lack access to conventional educational resources (Ibarrientos, 2024). The implementation of digital education matches worldwide education reforms because ICT plays an essential role in enhancing student performance and engagement. Research on technology-based assessments validates that computer-based testing systems improve student learning, both in motivation and efficiency, primarily within vocational education environments (Balan & Djuniadi, 2016). The research findings demonstrate how ICT can revolutionise Timor-Leste's primary education since it creates dynamic learning environments that benefit all students effectively.

The implementation of ICT within primary schools in Timor-Leste faces multiple difficulties that require resolution to establish the desired level of success. Limited infrastructure, insufficient teacher training, and disparities in digital access pose significant barriers to effective implementation (Lopes *et al.*, 2017). The lack of dependable internet access, combined with insufficient technological equipment, exists in rural and less fortunate educational institutions, which limits their ability to sustain regular ICT implementation in their teaching activities. The lack of proper training regarding digital educational tools leads teachers to identify themselves as unprepared to use these resources in their instruction. The resolution of these problems needs complete systems that include establishing infrastructure, special teacher education programs, and making sure all groups get equal access to technological resources. Timor-Leste will achieve maximum educational progress and develop an inclusive learning environment by conquering its present obstacles related to ICT adoption.

Educational institutions successfully integrate ICT, which functions as an essential element in modern teaching practices, with the ability to improve accessibility and educational effectiveness while increasing student engagement. Technology continues to evolve, so it serves as an educational transformation instrument that supports both academic staff and their students. ICT integration helps teachers implement modern educational methods while

supporting interactive learning processes and enabling students to access educational tools, specifically in distant and disadvantaged regions (Knezek *et al.*, 2019). ICT adoption improves student learning outcomes through the interactive learning experiences it provides when students receive personalized education and collaborate (Dawson *et al.*, 2010). There are multiple hurdles to incorporating ICT into educational curricula, such as the lack of suitable infrastructure, insufficient teacher readiness, and digital access disparities observed mostly in developing nations like Timor-Leste, despite its substantial benefits. Creating a strategic plan for barrier resolution requires funding technological infrastructure, as well as providing continuous education development for teachers, and making sure students have equal digital tools. The study reviews how ICT impacts education by discussing its effects on student participation as well as academic performance, and also explores the barriers that prevent effective technology integration.

2. LITERATURE REVIEW
2.1. Importance of ICT Integration in Education

Education modernisation through information and communication technology (ICT) implementation stands central for developing nations, such as Timor-Leste, as described by previous studies (Lucas *et al.*, 2015). The implementation of ICT creates adaptive educational spaces that help teachers boost student involvement and support group-based learning activities (Balol, 2023). Students benefit from using digital tools to discover an extensive selection of online materials that they could not previously access, thus deepening their educational journey. ICT adoption helps students learn critical 21st-century abilities that comprise problem-solving skills together with communication skills, and also critical thinking capacities. The modern economy requires these essential skills because they ensure students are ready for its digital and knowledge-oriented structure. ICT functions as an access and quality bridge for rural, underserved areas that lack traditional educational resources and trained educators. Learning analytics draws attention through research because it enhances instruction methods by adapting educational content to match individual student requirements (Shum & Luckin, 2019).

Integrating ICT provides chances to improve assessment strategies and educational material delivery processes. Computers used in testing demonstrate enhanced capabilities to measure academic results while detecting gaps in knowledge acquisition. Digital assessments offer both immediate, accurate feedback and personalized learning methods that direct students towards getting needed support through education (Balan & Djuniadi, 2016). ICT-based educational teaching methods allow students to become leaders in their educational journey through student-focused learning activities. To realize the advantages of ICT in education, institutions must have appropriate infrastructure, along with trained teachers and well-designed policy frameworks for implementation. Unresolved basic challenges hinder the full potential of ICT to transform education systems and enhance student learning performance. A successful ICT adoption for education in Timor-Leste requires an organized method that combines educator training programs with investments in technological systems.

2.2. Enhancing Learning Outcomes and Student Engagement

The primary school curriculum of Timor-Leste benefits from ICT implementation as it elevates educational achievements and boosts student investment. Educational practitioners should use ICT to implement different teaching techniques that support multiple student learning approaches, creating more inclusive classrooms. Digital tools support student-oriented active learning techniques that motivate students to learn better and, at the same

time, enhance their analytical skills and problem-solving aptitude (Chen & Huang, 2024). Through ICT, students can link with each other to complete assignments collectively as well as exchange learning materials through digital networking systems. Educators can adapt their teaching materials and evaluation methods to technology, which enables them to better serve individual students' needs through personalized learning. Learning analytics enhances the flexibility of classrooms by supplying student performance information for teacher identification of support priorities (Herodotou *et al.*, 2019).

ICT integration is an effective tool to address digital literacy shortcomings, particularly for women and girls who belong to marginalized communities. Technology delivery must be equally accessible, as it plays a crucial role in establishing education systems that welcome all students and enable them to thrive in the current digital society. Organizations that enhance digital literacy for marginalized groups create an educational balance among students and establish a digital workforce that benefits society. Timor-Leste needs to enhance its ICT proficiency since it establishes a basic requirement for global labor market access, according to the literature (Campos & Scherer, 2024). ICT integration in education demands significant financial investment, coupled with proper teacher education and government backing for effective and enduring implementation. The successful implementation of ICT in primary education requires immediate action to handle existing barriers that prevent students from meeting future professional needs.

2.3. Challenges of ICT Integration in the Curriculum

Timor-Leste faces substantial hurdles during the logical implementation of information and communication technology (ICT) in education, although the potential advantages exist. The insufficient teacher training stands as a main barrier since teachers cannot leverage ICT teaching tools properly (Lopes *et al.*, 2017). The lack of proper training platforms for teachers prevents them from effectively integrating digital tools into their educational methods, which reduces the possible benefits of ICT usage in student performance. The educational gap widens due to urban students having better access to ICT than their rural counterparts. Remote educational facilities run without sufficient electrical infrastructure or internet access, hindering students' ability to efficiently use online learning tools. The existence of digital inequality creates barriers against educational possibilities, which prevents students from underserved areas from acquiring the relevant digital competencies required to succeed both academically and professionally (Asian Development Bank in 2023; see https://doi.org/10.22617/FLS230039). A solution for this problem needs extended ICT infrastructure funding, combined with specialized teaching methods and policies that regulate educational technology accessibility for all students.

Digitally marginalising women and girls becomes more important because of the digital literacy differences that remain a significant obstacle to IT integration. Research shows that ASEAN nations, including Timor-Leste, confront major obstacles that prevent women from learning digital skills, thereby reducing their participation in educational and career options (Campos & Scherer, 2024). Various factors create these educational inequalities among female learners, such as cultural norms, inadequate access to digital devices, and gender-specific training programs. Only after implementing specific solutions to their gender-related learning obstacles can women and men increase their educational advantages through ICT integration. For the complete use of ICT benefits in education, Timor-Leste needs to develop inclusive policies that provide digital literacy training to all students, regardless of their gender or social status. Digitally trained resources for women, combined with better ICT equipment

and training programs for teachers, will be vital elements in making technological integration equal and effective in Timor-Leste's educational framework (Grande-De-Prado *et al*., 2020).

3. METHOD

This study utilized the systematic literature review (SLR) methodology, which followed PRISMA guidelines, to study information and communication technology's (ICT) implementation in the 2014 primary school curriculum in Timor-Leste (Selçuk, 2019). The research implemented a systematic search through academic databases like Google Scholar, JSTOR, ERIC, and Scopus, and additional government reports and credible resources. The research scope included academic articles and reports, which spanned from 2016 to 2024 and utilized the search terms "ICT integration in primary education" together with "Timor-Leste primary school curriculum 2014", "educational technology in Timor-Leste", "learning outcomes and ICT," and "digital literacy in Timor-Leste." The chosen search terms focused on research about how ICT affects student connections and teaching success, as well as fair education in low-income countries like Timor-Leste. The previous papers (Msambwa & Daniel, 2024) showed that the chosen research met certain criteria, which involved looking at how ICT is used in primary schools and its effects on the quality and availability of education in developing countries.

Each study underwent systematic data extraction; its main target areas included location, objectives, methodology, findings, and proposed recommendations (Büchter *et al*., 2020). The research methodology produced complete documentation of ICT potentials and barriers that exist during implementation within Timor-Leste's educational framework. All studies received individual quality assessments to validate their reliable content. The evaluation process focused on testing research question clarity, research design selection, validation of data gathering methods, and the accuracy of reported results. The data extraction process helped the researchers combine findings from different studies, making it easier to spot common patterns and trends in ICT integration. The analysis revealed key consensus about teacher training being essential, along with beneficiary technology distribution and technical need resolution for digital education success. The systematic review faced limitations due to publication bias and the exclusion of studies written in languages other than English or Portuguese. While these constraints influenced review comprehensiveness, the methodology delivered a comprehensive critical evaluation regarding ICT integration in education for Timor-Leste and similar educational settings.

4. RESULTS AND DISCUSSION

The research demonstrated that teaching with Information and Communication Technology (ICT) produced notably high learning achievements. The interactive nature of information and communication technology tools led to complete student engagement while boosting overall motivation levels and better understanding, according to teachers and students. The digital resources allowed students to participate more actively in their learning because they provided multiple learning experiences suitable for different learning approaches. Digital learning materials show tremendous value when supplying educational content to the students who live in remote locations where traditional educational resources are scarce. The study reveals how information and communication technology supports equality-based education through improved material distribution, which elevates learning outcomes for disadvantaged students (Campos & Scherer, 2024; Balan & Djuniadi, 2016). IT systems act as a powerful instrument for building educational resilience in difficult situations

such as Timor-Leste because they bring basic educational resources to marginalized populations, according to the Asian Development Bank in 2023 (see https://doi.org/10.22617/FLS230039).

The study found various substantial obstacles that prevent the effective implementation of ICT integration in educational institutions, although its numerous benefits are obvious. The success of technology integration in classrooms is hindered by insufficient training for teachers about ICT, which presents a major hurdle to achieving the wide adoption of educational technology tools. The majority of teachers admitted their limited readiness to use ICT tools, along with their insufficient educational background for integrating technology into their instructional methods. This shortage points to the need for better professional training. The study supports previous papers (Shymansky *et al.*, 2013) reported that supplying teachers with thorough training regarding ICT helps achieve maximum efficiency. Traditional infrastructure problems, such as unstable power supply and internet access, worsen the complete adoption of ICT, especially in rural regions. The unstable infrastructure causes interruptions in learning as well as operational challenges for digital tools in certain contexts. Developing the physical framework, along with enhancing connectivity, represents a critical element for integrating ICT across global regions since it enables technology to optimize educational results (Jung, 2005).

The research demonstrated that equity issues surfaced as a main issue through the study because different demographic groups experienced substantial differences in ICT access. A gender-based disparity in digital capabilities is a significant problem, as women face additional obstacles in using and accessing ICT. Women face limited opportunities to join the technological landscape and exploit educational advantages due to gender-based inequalities, which help maintain gender inequality in the education sector (Grande-de-Prado *et al.*, 2020). The acquisition of ICT tools, including personal digital devices, becomes difficult for students whose educational experiences are impacted by economic inequality, leading to a deterioration of independent learning in digital classrooms. Students coming from low-income households could not buy needed digital devices or maintain them, which created additional educational inequality issues. Research evidence creates an urgent demand for specific programs that will provide technology access equally to all students regardless of their economic situation and gender, while making it possible for everyone to take advantage of technology-enhanced learning. The achievement of equitable learning opportunities depends on comprehensive policies that connect gender and resource limitations (Chisamya *et al.*, 2012).

The study concludes that ICT integration will improve outcomes through equitable resource access, but its success depends on resolving training issues, infrastructure challenges, and social equity obstacles. The complete benefits of ICT educational transformation in Timor-Leste might be unattainable unless key improvements occur. A complete technology integration strategy needs professional development alongside infrastructure expansion, as well as gender and socio-economic equity policies to guarantee technological learning benefits for all students. The findings support suggestions by the Asian Development Bank in 2023 (see https://doi.org/10.22617/FLS230039), together with educational stakeholders, regarding how to improve regional educational quality.

4.1. Infrastructure and Resource Limitations in Timor-Leste's Educational System

The educational growth of Timor-Leste encounters ongoing obstacles to incorporating ICT because of persistent resource-based and infrastructure-centered issues that affect schools. Physically inadequate educational institutions lack proper building maintenance, and they do

not have adequate access to water and electricity. Rural and remote locations experience the worst infrastructure problems because they have no dependable power connection and lack internet access, which limits their ability to use ICT tools in teaching practices (Park *et al.*, 2019). The deficiencies in basic infrastructure create operational problems in schools and prevent educational modernisation projects that use technology. The insufficient financial investment in education worsens existing challenges because it restricts both technology procurement and support facility development (Munje & Jita, 2020).

The educational system of Timor-Leste faces limits to ICT implementation success due to insufficient human resources. The number of expert ICT teachers in schools remains low since most educators need improved training before feeling capable of using technology in their classroom instruction. Professional development opportunities, along with technical help, are scarce, so teachers struggle to solve technology-related classroom issues (Al-Rahmi *et al.*, 2020). The Partnership for Human Development and the ALMA program struggle to address core human resource issues because they focus on educational reforms rather than specific ICT training (Kozma, 2005). Education in Timor-Leste can achieve full ICT transformation through an integrated methodology that handles infrastructure deficiencies alongside human resource development steps.

4.2. Strategic Approaches for Effective ICT Integration

A complete strategy consisting of educator training as well as infrastructure improvements and regulatory changes needs to be implemented to manage the unique obstacles limiting Information and Communication Technology integration in Timor-Leste's educational settings. Teachers hold a central role in the digital transformation, so training programs must deliver advanced technical skills and teaching techniques to integrate ICT in educational practices. Readiness among teachers represents an essential factor that impacts ICT success in restricted educational settings (Shymansky *et al.*, 2013). Training programs must build educators' skills in both technology usage and educational practices that utilise digital instruments to activate students, deliver tailored approaches, and conduct performance-based evaluations. The combination of technical implementation with instructional application prevents the underutilisation of ICT (Rana & Rana, 2020). Teachers who attain competence in ICT use create an influence for classroom innovation, which enhances digital literacy education and produces inclusive learning spaces in schools with resource constraints.

The foundation of ICT-enabled education requires the simultaneous establishment of infrastructure, which enables its functioning. The majority of Timor-Leste faces challenges regarding steady power supplies, minimal broadband infrastructure, and declining school infrastructure maintenance, which prevents reliable ICT adoption (Anggraeni *et al.*, 2025). To guarantee fair usage of technology-based educational settings, it is vital to invest in things like stabilized electric power systems, networks, and long-lasting digital gear. Previous reports (Shum & Luckin, 2019) emphasized policy coherence by recommending that ICT integration needs to fit into the national education strategies, where both infrastructure and technology development play significant roles. By concurring teacher capacity development with infrastructure improvement along with national educational requirements, Timor-Leste can achieve ICT as an essential element of its quality education system. ICT functions as a fundamental strategy to achieve educational justice and transform educational systems in modern educational environments.

4.3. Equity and Inclusion in ICT Integration

Timor-Leste must create a detailed plan aimed directly at the digital divide to achieve equity and inclusion when integrating ICTs into its educational system. The lack of digital resources affects learners from impoverished families as well as children from remote areas and female students who must overcome cultural hurdles when using technology (Grande-de-Prado *et al.*, 2020). Gender-sensitive ICT programs serve as essential tools that reduce inequalities by creating equal digital learning conditions for boys and girls through their development. The United Nations Educational, Scientific, and Cultural Organisation (UNESCO in 2023; see https://doi.org/10.54676/IJDN3924) carries research evidence that demonstrates that gender-focused ICT education programs enhance equality and produce overall social and economic empowerment. We must address the perspectives of students with disabilities, as they constitute a crucial element in creating a digital education framework that encompasses everyone. Using assistive technology along with developing an ICT curriculum to meet different learning needs allows all students to benefit from technology-based learning, creating a fairer education system.

It is essential to address the economic gaps, which will enable all students in Timor-Leste to join ICT-driven learning environments. Digital device and internet connectivity shortages continue to obstruct students from disadvantaged schools, which further widens educational gaps (Reynolds *et al.*, 2022). The problems can be solved through policies focused on device affordability by utilizing corporate partnerships with government assistance, subsidized hardware programs, and public-private alliances to develop internet access networks in remote areas. Two kinds of evidence indicate that funds for student access and digital learning hubs located in communities help economically deprived students succeed more effectively (Warschauer & Matuchniak, 2010). To provide students with technology accessibility and teach them how to use it effectively, curriculum development must include digital literacy training. A combination of programs will guide Timor-Leste towards creating an ICT-based educational system that provides equal opportunities to all students, regardless of social position or economic background. ICT-based education system reform in Timor-Leste will lead to improved equality through these implemented measures and student empowerment across all demographics.

4.4. A Holistic Approach to ICT Integration

A full-scale plan that tackles various issues becomes fundamental for the successful implementation of Information and Communication Technology (ICT) within Timor-Leste's educational framework. The infrastructure challenges persist as the majority of rural and remote areas in Timor-Leste lack reliable electricity and internet connectivity, which limits effective ICT-based learning opportunities, according to UNESCO in 2023 (see https://doi.org/10.54676/IJDN3924). Teachers require continuous professional development to enhance their digital teaching skills, as many lack adequate experience with ICT in classroom settings. We must equally guarantee technology accessibility to prevent the growth of educational inequalities between students from different social classes. The successful implementation of ICT in schools requires government collaboration with educational institutions, together with international partnerships, to resolve these structural barrier issues (Younie, 2006).

The complete transformation of ICT depends on developing both the educational environment and the training of ICT professionals. Teaching curricula must be modified to embed digital literacy and ICT competency training because this enables students to succeed in a digital society, according to UNESCO in 2023 (see https://doi.org/10.54676/IJDN3924). It is essential to create content that suits Timor-Leste's cultural background and language

because many existing digital resources do not match the context. Students will experience better engagement through enhanced accessibility when high-quality digital content is developed in Tetum, along with other local languages. Long-term ICT implementation is dependent on sustainable policies that develop public-private partnerships that will help resolve funding shortages (Younie, 2006). Timor-Leste needs to focus on these critical areas, as doing so will foster an education system rooted in inclusive innovation through digital technology. This approach enhances learning performance and develops students' digital skills for active participation in the global knowledge economy.

4. CONCLUSION

An effective integration of ICT into Timor-Leste's primary school curriculum demands simultaneous improvements in infrastructure, teacher development, and content creation specific to the area. The implementation of ICT programs requires dependable technological infrastructure across all regions, especially rural locations, since their success depends heavily upon such infrastructure. The barrier to successful ICT-driven learning includes unstable power supply, insufficient internet connections, and a lack of digital hardware. Comprehensive digital infrastructure and strategic tech partnerships defined by Nigerian institutions, as seen in Thailand and Vietnam, arise from governmental support (Asian Development Bank in 2023; https://doi.org/10.22617/FLS230039). Timor-Leste will need government-directed infrastructure-building efforts to establish ICT as an effective teaching instrument rather than an extra task for both trainers and learners.

School success with ICT integration depends heavily on educating instructors properly since teachers have the essential role of guiding technology-fueled educational pursuits. The educational professionals of Timor-Leste need specialized training programs to learn digital tool applications properly for effective integration of ICT in classroom teaching. The combination of extended educational programs, which include mentoring support and peer collaboration between teachers, leads to significant improvement in their digital resource proficiency (UNESCO in 2023; see https://doi.org/10.54676/IJDN3924). Educational programs need a contextualized design to make sure instructors learn about ICT tools and acquire skills to integrate them throughout their curriculum-based lessons and classroom practice. Inadequate training combined with insufficient support erodes the potential of technology implementation, which then reduces its intended effect on academic results for students. The government's investment in ongoing professional development of its instructors will enable the country to establish teaching staff who effectively integrate information communication technology to elevate educational delivery.

The research shows that implementing information and communication technology requires simultaneous efforts to reduce digital exclusion barriers so every learner, regardless of social status, obtains digital educational benefits. Many developing countries, such as Timor-Leste, experience educational disparities because disadvantaged students encounter major hurdles when trying to access digital learning resources (Asian Development Bank in 2023; see https://doi.org/10.22617/FLS230039). The implementation of policies that focus on fair technology distribution and discounted internet services, along with technological facilities based in educational institutions, works to reduce the disparities among students. Students will gain improved educational outcomes when digital content is localized with culturally relevant and multilingual resources because it makes ICT-driven education more successful. The review shows that a proper ICT implementation strategy, combined with infrastructure development, teacher readiness, and equitable access channels, will extract the maximum value from digital integration. Timor-Leste will develop a modern education

system with inclusive features and digital resilience by implementing comprehensive approaches to these vital factors.

Future programs require a holistic methodology corresponding to local conditions to implement ICT effectively. Academic experts (Delprato & Shephard, 2024; Wong et al., 2023) proposed successful approaches that provide helpful guidelines to create specific ICT programs for Timor-Leste. The approaches call attention to technology adoption practices that adjust technology according to local educational situations to handle unique educational system challenges.

Partnerships involving government institutions, educational organisations, and international organisations are necessary to sustain ICT initiatives. The Asian Development Bank in 2023 (see https://doi.org/10.22617/FLS230039) recommends data-driven strategies, which will generate a systematic approach to assess and improve ICT integration throughout the years. The commitment to partnerships among stakeholders will help deliver an organized method for resolving ICT adoption problems in educational institutions.

The implementation of solutions to infrastructure, training needs, and contextual alignment problems described in this review will allow Timor-Leste to establish a sustained educational framework that ensures fairness within schools. These initiatives help schools integrate ICT through infrastructure improvements while allowing technology to resolve present and future educational problems to deliver meaningful learning outcomes to all student populations.

5. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

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