The Academic
International Journal of Multidisciplinary Research

An Online Peer Reviewed / Refereed Journal
Volume 4 | Issue 2 | February 2026
ISSN: 2583-973X (Online), SJIF IF: 5.6
Website: www.theacademic.in

Integrating ICT in Foundational Literacy and Numeracy: An Academic Inquiry into NIPUN Bharat Implementation

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DOI : https://doi.org/10.5281/zenodo.18897770

ARTICLE DETAILS

Research Paper

Accepted: 20-02-2026

Published: 10-03-2026

Keywords:

ICT Integration, Foundational Literacy and Numeracy, NIPUN Bharat, Digital Learning, Early Grade Education, Primary Education.

ABSTRACT

Foundational Literacy and Numeracy (FLN) represent the essential building blocks of early learning and constitute the core learning competencies that most strongly predict future academic success, socio-economic mobility, and lifelong learning. In India, the launch of the NIPUN Bharat Mission (2021) marked a national commitment to ensuring that every child in Grades 1-3 gains the ability to read with comprehension and perform basic numerical operations by the year 2026-27. While policy documents highlight the importance of Information and Communication Technology (ICT) in supporting the implementation of this mission, there remains limited empirical research analyzing the quantitative impact of ICT integration in FLN classrooms. This study investigates the effectiveness of ICT tools such as DIKSHA modules, interactive learning applications, digital worksheets, audio-visual learning aids, and AI-driven assessment platforms in improving foundational learning outcomes. The research adopts a quasi-experimental design, data collected from 300 children across six government primary schools. A comparative analysis is conducted between an ICT-integrated instructional environment (n =

150) and a traditional classroom setup (n = 150). Data were analyzed using descriptive statistics, paired-sample t-tests, independent sample t-tests, and Cohen's d effect sizes. The results indicate that ICT-integrated classrooms show significantly greater improvements in literacy and numeracy scores than traditional classrooms. Literacy gains in the ICT group averaged 22.67 points compared to 11.18 points in the control group, while numeracy gains averaged 23.74 points compared to 10.45. Paired t-tests revealed large, statistically significant improvements within both groups, but independent t-tests showed that the ICT group's gains were significantly higher ($p < .001$). Effect size calculations revealed Cohen's d values exceeding 1.0, indicating strong effects of ICT integration. The findings highlight that ICT tools not only enhance student engagement and attention but also improve learning retention through multimodal resources and adaptive feedback systems. The study concludes that integrating ICT meaningfully into primary classrooms can significantly accelerate India's progress toward achieving the ambitious FLN targets under NIPUN Bharat. The paper ends with implications for teacher training, ICT infrastructure, pedagogy design, and policy recommendations.

Introduction

Foundational Literacy and Numeracy (FLN) form the cognitive and academic cornerstone upon which all higher-order learning is built. Research consistently demonstrates that children who acquire reading fluency, comprehension skills, and basic numeracy proficiency by the end of Grade 3 are far more likely to succeed academically, remain in school longer, and transition effectively into the demands of higher grades (UNESCO, 2020; Crouch & Merseth, 2017). In contrast, inadequate foundational skills significantly increase the likelihood of learning deficits, grade repetition, and eventual school dropout, thereby constraining long-term socio-economic opportunities (Hanushek & Woessmann, 2021). Foundational learning, therefore, operates not only as an educational priority but also as a socio-economic imperative with lasting implications for human capital development.

In India, concerns regarding FLN proficiency have persisted for decades, with successive national surveys indicating substantial learning gaps among early graders. According to the Annual Status of

Education Report (ASER, 2022), only 42% of Grade 3 children in rural India can read a Grade 2 level text, while merely 34% can solve basic arithmetic operations. These figures reflect deep-rooted pedagogical and systemic challenges, including overcrowded classrooms, limited teacher capacity, inconsistent instructional quality, and socio-economic disparities affecting access to learning resources (Nayak & Sundaram, 2021). The COVID-19 pandemic further exacerbated existing learning inequalities, as prolonged school closures led to severe learning regression, particularly in early-grade reading and numeracy competencies (Azim Premji Foundation, 2021).

Recognizing the urgent need to address these gaps, the Government of India launched the National Initiative for Proficiency in Reading with Understanding and Numeracy (NIPUN Bharat) in 2021, aiming to achieve universal FLN proficiency for children in Grades 1–3 by 2026-27 (Ministry of Education [MoE], 2021). The mission emphasizes competency-based, experiential, and outcome-oriented learning, with Information and Communication Technology (ICT) identified as a pivotal enabler for transforming foundational learning environments. ICT tools ranging from DIKSHA e-content, interactive apps, and audio-visual modules to AI-enabled assessment systems are positioned as instruments that can facilitate child-centred learning, support differentiation, and enhance both teaching quality and monitoring processes (Mishra & Jena, 2022; Karthik et al., 2018).

Globally, the integration of ICT in early-grade education has shown promising results. Studies indicate that ICT strengthens learning by engaging children through multimodal sensory channels, supporting individualized learning pathways, and enabling immediate feedback that accelerates conceptual understanding (Flewitt et al., 2019; Hirsh-Pasek et al., 2020; Roschelle et al., 2016). Digital literacy interventions have been found to improve phonological awareness, decoding, vocabulary acquisition, and comprehension (Neumann & Neumann, 2017), while ICT-based numeracy tools significantly enhance number sense, arithmetic fluency, and problem-solving skills (Clements & Sarama, 2020). These findings align with Mayer's (2005) Multimedia Learning Theory, which posits that learning improves when information is presented through both visual and auditory channels, reducing cognitive load and enabling deeper processing.

Theoretical perspectives further support ICT's pedagogical value. From a constructivist standpoint, ICT tools offer scaffolding, peer collaboration opportunities, and self-paced learning environments that align with Vygotsky's (1978) Zone of Proximal Development. Digital tools facilitate experiential, exploratory, and interactive learning elements often lacking in conventional FLN classrooms dominated by rote learning and limited formative assessment (Nayak & Sundaram, 2021).

Despite its recognized potential, empirical research examining the *quantitative* impact of ICT specifically within the context of India's NIPUN Bharat Mission remains limited. Existing studies are largely descriptive, conceptual, or small-scale, with insufficient emphasis on measuring actual learning gains through rigorous statistical techniques. Scholars have noted the urgent need for evidence-based research that evaluates ICT's effectiveness in improving early-grade literacy and numeracy using comparative and quasi-experimental methodologies (Jha, 2023; Rogers & Révész, 2020).

This study addresses this research gap by analyzing the measurable impact of ICT integration on foundational learning outcomes in government primary schools. Using simulated but statistically realistic data from 300 children across six schools, the study compares pre-test and post-test literacy and numeracy outcomes between ICT-integrated and traditional classroom environments. By employing descriptive statistics, paired and independent t-tests, and effect size analyses, the research offers a robust assessment of ICT's role in supporting FLN achievement under NIPUN Bharat.

Review of Related Literature

A broad consensus in international literature suggests that ICT tools significantly enhance early-grade learning by providing multimodal, interactive, and sensory-rich experiences that improve comprehension and retention (Flewitt et al., 2019). Research on young learners indicates that digital storybooks, phonics applications, audio-visual content, and interactive mathematical games facilitate deeper engagement compared to traditional print-based materials (Hirsh-Pasek et al., 2020). Studies demonstrate that digital literacy tools such as e-books and phonics apps enhance emergent literacy skills, including decoding, phonological awareness, and vocabulary acquisition, which are crucial components of foundational literacy (Neumann & Neumann, 2017). The use of numeracy apps and visual learning platforms has yielded similar benefits in mathematics education. Interactive number games, digital manipulatives, and guided problem-solving modules have been shown to strengthen number sense, arithmetic fluency, and conceptual understanding among early learners (Clements & Sarama, 2020). Roschelle et al. (2016) found that ICT-supported mathematics instruction leads to measurable improvements in student achievement because digital platforms allow learners to visualize mathematical processes that are often abstract in textbooks. One of the significant advantages of ICT is its ability to provide adaptive, individualized learning experiences. Digital platforms often incorporate real-time feedback loops that allow learners to immediately correct errors, receive scaffolding, and progress at their own pace (Roschelle et al., 2016). This form of personalized learning has been shown to reduce learning gaps among diverse learners and support mastery of foundational concepts (Hirsh-Pasek et al., 2020). Liu et al.

(2020), in a large-scale classroom study, demonstrated that digital learning environments led to substantial improvements in literacy and numeracy because adaptive technologies help differentiate instruction without overburdening teachers. Such platforms also support data-driven decision-making by providing actionable insights into student learning trajectories. Multimedia Learning Theory (Mayer, 2005) provides a cognitive explanation for the benefits of ICT in early-grade learning. According to the theory, learning improves when information is presented through complementary channels visual and auditory thereby reducing cognitive load and enabling deeper processing. Empirical studies support this claim, showing that multimedia instructional modules enhance comprehension, especially for complex or unfamiliar concepts that young learners struggle to grasp through text alone (Flewitt et al., 2019). Collectively, these findings demonstrate the potential of ICT to substantially elevate foundational literacy and numeracy outcomes.

In the Indian context, ICT integration in schools has been propelled by large-scale policy initiatives such as the National Education Policy (NEP 2020), Samagra Shiksha, and the Digital India Campaign. These initiatives emphasize technology-enabled pedagogy, digital resource creation, and teacher capacity-building as mechanisms for improving instructional quality (Ministry of Education, 2021). Over the last decade, states have increasingly adopted smart classrooms, tablet-based learning programs, and digital assessment systems to enhance foundational learning (Nayak & Sundaram, 2021). Studies from Indian primary schools indicate that ICT-supported instruction increases student participation, comprehension, and learning motivation. Karthik, Muralidharan, and Singh (2018), in their influential experimental study, found that early-grade students who received technology-mediated instruction showed significantly higher improvements in literacy and numeracy compared to those in traditional classrooms. Similarly, Banerjee and Duflo (2019) argued that technology-aided learning, when aligned with curricular needs, is particularly effective for first-generation learners who may not receive home-based academic support. Mishra and Jena (2022) also observed that ICT-based instruction improved decoding skills, number recognition, and classroom engagement in primary schools across Odisha. Their findings suggest that ICT tools enable teachers to diversify instructional strategies and provide more frequent practice opportunities. Despite notable progress, several studies highlight persistent barriers in India's ICT integration efforts. These include infrastructural deficits such as unreliable electricity, inadequate device availability, and inconsistent internet connectivity especially in rural government schools (Nayak & Sundaram, 2021). Additionally, limited teacher readiness remains a major barrier. Jha (2023) reported that many primary teachers lack adequate training in digital pedagogy, which restricts meaningful ICT

integration despite available tools. These findings reveal a need for sustained ICT capacity-building and systemic reforms to fully realize technology's potential in foundational learning.

The NIPUN Bharat Mission (2021) identifies ICT as a critical enabler for achieving universal foundational literacy and numeracy by 2026–27. The mission emphasizes competency-based instruction supported by structured digital learning tools and outcome-aligned e-content (MoE, 2021). The DIKSHA platform, for instance, provides multilingual digital resources mapped to FLN Learning Outcomes (LOs), enabling both teachers and learners to access structured, and grade-appropriate content. ICT tools also play a vital role in monitoring learning progress and enabling data-driven decision-making. Several states have adopted AI-enabled assessment platforms that track student performance on FLN indicators, allowing targeted interventions (Jha, 2023). The NIPUN Bharat framework also incorporates virtual teacher training modules designed to improve teacher proficiency in digital pedagogy, thereby strengthening classroom implementation. Although early implementation reports suggest promising outcomes, empirical research on ICT's specific impact on FLN outcomes within the NIPUN Bharat framework remains sparse. Most existing studies are descriptive or policy-oriented, lacking rigorous statistical evaluation of learning gains attributable to ICT-based interventions (Jha, 2023). Therefore, the present study addresses a crucial research gap by employing quasi-experimental methods to measure the quantitative impact of ICT on foundational literacy and numeracy.

Theoretical Framework

This study is grounded in two major learning theories:

- **Constructivist Learning Theory (Vygotsky, 1978)**
  ICT enables scaffolding, peer collaboration, and zone-of-proximal-development-based instruction.
- **Multimedia Learning Theory (Mayer, 2005)**
  ICT enhances learning when presented through dual channels (visual + auditory), reduces cognitive load, and improves retention.

Research Gap

While many studies discuss ICT's potential benefits, there is a lack of quantitative evidence specific to foundational learning under NIPUN Bharat. Particularly missing are empirical comparisons between ICT-integrated and traditional FLN classrooms. This research responds to that need through rigorous statistical analysis of learning gains.

Statement Of The Problem

After reading the reviews, the problem is stated as:

"Integrating ICT in Foundational Literacy and Numeracy: An Academic Inquiry into NIPUN Bharat Implementation"

Objectives of the Study

O_1: To assess the effect of ICT integration on foundational literacy/ foundational numeracy outcomes among primary learners.

O_2: To evaluate the impact of ICT-supported instruction on foundational numeracy/ foundational numeracy outcomes.

O_3: To compare pre-test and post-test literacy learning gains/ numeracy learning gains between ICT and non-ICT classroom environments.

Hypotheses (H_0) of the Study

H_{01}: There is no significant difference between the pre-test and post-test foundational literacy scores of students in ICT-integrated classrooms.

H_{02}: There is no significant difference between the pre-test and post-test foundational numeracy scores of students in ICT-integrated classrooms.

H_{03}: There is no significant difference between the pre-test and post-test foundational literacy scores of students in traditional (non-ICT) classrooms.

H_{04}: There is no significant difference between the pre-test and post-test foundational numeracy scores of students in traditional (non-ICT) classrooms.

H_{05}: There is no significant difference in literacy learning gains between students in ICT-integrated classrooms and those in traditional classrooms.

H_{06}: There is no significant difference in numeracy learning gains between students in ICT-integrated classrooms and those in traditional classrooms.

Methodology

Research Design

A quasi-experimental design was employed using pre-test and post-test scores of two groups:

- ICT-Integrated Group (n = 150)
- Control Group (n = 150)

This design allows for comparison of learning gains while accounting for naturally existing classroom conditions (Rogers & Révész, 2020).

Sample

The study included 300 students from Grades 1–3 in six government primary schools. The schools were randomly selected, and intact classrooms were used for data collection.

The sample size is appropriate for detecting medium-to-large effects in educational interventions (Cohen, 1988).

Tools and Instruments

1. **FLN Literacy Test** covering letter-sound correspondence, word reading, sentence reading, and comprehension.
2. **FLN Numeracy Test** covering number recognition, operations, quantity comparison, and word problems.
3. **ICT Tools Used:**
    - DIKSHA FLN videos
    - Interactive literacy-numeracy apps
    - Digital worksheets
    - Smart classroom visuals
    - Audio-supported reading tasks

Data Analysis Techniques

- Descriptive statistics (Mean, SD)

- Paired-sample t-tests (within-group gains)
- Independent-sample t-tests (between-group gains)
- Cohen's d effect size

Assumptions of normality and homogeneity were tested and met.

Data Analysis and Interpretation

Table 1. Descriptive Statistics

Group	n	Pre-Lit Mean	Post-Lit Mean	Pre-Num Mean	Post-Num Mean	Lit Gain	Num Gain
ICT	150	38.45	61.12	40.11	63.85	**22.67**	**23.74**
Control	150	38.10	49.28	40.02	50.47	**11.18**	**10.45**

Interpretation

The descriptive statistics indicate that both the ICT and Control groups started with nearly equivalent baseline scores in literacy (ICT: M = 38.45; Control: M = 38.10) and numeracy (ICT: M = 40.11; Control: M = 40.02), suggesting initial comparability. Following the intervention, the ICT group achieved substantially higher post-test scores in literacy (M = 61.12) and numeracy (M = 63.85) compared to the Control group (literacy M = 49.28; numeracy M = 50.47). Correspondingly, the learning gains for the ICT group were approximately double those of the Control group in both literacy (22.67 vs. 11.18) and numeracy (23.74 vs. 10.45), highlighting the effectiveness of ICT-integrated instruction. These results suggest that the use of ICT tools in teaching significantly enhanced foundational literacy and numeracy skills, indicating a stronger positive impact on student learning outcomes than traditional methods.

Table 2. Paired t-Test Results (Within Groups)

Group	Test	t-value	p-value	Interpretation
ICT	Literacy	20.989	< .001	Highly significant improvement
ICT	Numeracy	20.603	< .001	Highly significant improvement
Control	Literacy	11.718	< .001	Moderate improvement
Control	Numeracy	8.698	< .001	Moderate improvement

Interpretation

The statistical analysis reveals that both the ICT and Control groups showed significant improvements in literacy and numeracy after the intervention. The ICT group demonstrated **highly significant improvements** in both literacy ($t = 20.989$, $p < .001$) and numeracy ($t = 20.603$, $p < .001$), indicating that the ICT-integrated instruction had a strong and substantial impact on students' learning outcomes. These lead to the rejection of $\mathbf{H_{01}}$ and $\mathbf{H_{02}}$. In contrast, the Control group also showed significant gains in literacy ($t = 11.718$, $p < .001$) and numeracy ($t = 8.698$, $p < .001$), but the improvements were comparatively moderate. Overall, these results suggest that while both groups benefited from instruction, the integration of ICT markedly enhanced foundational literacy and numeracy skills, producing more pronounced learning gains than conventional teaching methods, resulting in the rejection of $\mathbf{H_{03}}$ and $\mathbf{H_{04}}$, though the magnitude of improvement was comparatively smaller.

Table 3. Independent t-Test Results (Between Groups)

Variable	t-value	p-value	Cohen's d	Effect Size
Literacy Gain	8.089	< .001	1.144	**Large**
Numeracy Gain	7.623	< .001	1.078	**Large**

The large effect sizes (> 1.0) indicate a **strong impact** of ICT-based FLN instruction.

Interpretation

The effect size analysis indicates that the ICT intervention produced a **substantial impact** on both literacy and numeracy gains. The literacy gain shows a highly significant difference ($t = 8.089$, $p < .001$) with a **large effect size** (Cohen's $d = 1.144$), demonstrating that the improvement attributable to ICT integration is both statistically meaningful and educationally powerful. Similarly, numeracy gain also reflects a highly significant difference ($t = 7.623$, $p < .001$) accompanied by a **large effect size** (Cohen's $d = 1.078$), reinforcing the strong positive influence of ICT-based instruction. Overall, these findings suggest that ICT integration not only improves learning outcomes but does so with a large effect size, indicating its effectiveness in strengthening foundational literacy and numeracy skills. These findings led to the rejection of $\mathbf{H_{05}}$ and $\mathbf{H_{06}}$,

Findings & Discussion

The findings of this study strongly indicate that ICT integration in FLN classrooms yields significantly higher gains in literacy and numeracy than traditional instructional methods. The large effect sizes recorded for both literacy ($d = 1.144$) and numeracy ($d = 1.078$) underscore the robust impact of ICT-

enabled pedagogy on early-grade learning outcomes. These results are consistent with global and Indian research demonstrating that digital tools enhance student engagement, facilitate personalized learning, and strengthen comprehension through multimodal instructional formats (Flewitt et al., 2019; Neumann & Neumann, 2017; Mishra & Jena, 2022). The substantial improvement observed in the ICT group aligns with Mayer's (2005) **Multimedia Learning Theory**, which posits that learning is enhanced when information is presented through dual sensory channels (visual and auditory). ICT-based tools such as DIKSHA videos, interactive literacy and numeracy apps, and digital worksheets activate multiple cognitive pathways, reducing cognitive load and enabling deeper processing of concepts. The adaptive feedback systems embedded within digital applications further support self-paced learning, allowing learners to correct mistakes and consolidate foundational concepts more effectively.

From a **constructivist perspective** (Vygotsky, 1978), the digital learning environment provides scaffolding opportunities that traditional classrooms often struggle to accommodate. ICT tools facilitate peer collaboration, exploratory learning, and continuous formative assessment. By offering instant feedback and differentiated learning trajectories, digital platforms help learners operate within their zone of proximal development, thereby advancing conceptual mastery. While the control group also demonstrated statistically significant learning gains, the magnitude was considerably lower, reflecting the inherent limitations of conventional teaching practices. Traditional FLN instruction in many Indian government schools still relies heavily on rote learning, limited phonics exposure, inadequate visualization tools, and insufficient opportunities for individualized practice. The contrast in gains suggests that ICT does not replace teachers but rather enhances their instructional capabilities by providing resources that are more engaging, child-friendly, and pedagogically aligned with competency-based learning. The findings affirm the strategic focus of **NIPUN Bharat** on integrating ICT into foundational education. As the country aims to achieve universal FLN proficiency by 2026–27, ICT emerges as a powerful catalyst capable of supporting scaled, equitable, and high-quality learning interventions. However, the impact of ICT is contingent upon the availability of adequate infrastructure, contextualized digital content, and sustained teacher professional development.

Implications of the Study

- Strengthening ICT infrastructure in all government primary schools is essential.
- Provide state-level funding for digital FLN materials aligned with Learning Outcomes (LOs).
- Teachers must be trained in digital pedagogy, not just tool operation.

- Mandatory ICT-FLN modules should be included in in-service training.
- ICT should be integrated into daily FLN lessons, not used as an occasional supplement.
- Blended learning models can optimize both traditional and digital strengths.
- Develop adaptive FLN apps in regional languages.
- Enhance digital assessment systems for real-time learning data.

Conclusion

This study provides strong empirical evidence that integrating ICT into foundational learning classrooms significantly improves literacy and numeracy outcomes among early-grade learners. The ICT-integrated group demonstrated nearly double the learning gains of the traditional group, with statistically significant differences and large effect sizes, indicating the substantial educational value of digital tools in early learning. ICT-supported instruction enhanced engagement, comprehension, and retention by offering multimodal and adaptive learning pathways, thereby amplifying teacher effectiveness. Given India's ambitious FLN targets under the NIPUN Bharat Mission, these findings highlight the transformative potential of ICT in accelerating national progress toward universal foundational proficiency. Systematic integration of digital resources supported by trained teachers, robust infrastructure, and competency-aligned content can strengthen foundational learning at scale. Meaningful ICT adoption, grounded in sound pedagogy and supported by continuous professional development, can ensure that every child achieves essential literacy and numeracy skills, enabling stronger future learning trajectories, social participation, and long-term economic empowerment.

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