



Digital Learning Transformation: An Analysis of the Effectiveness of EdTech Platforms in Enhancing Secondary School Students' Digital Literacy Transformasi

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ABSTRACT

This systematic review synthesizes empirical on the effectiveness of educational technology (EdTech) platforms for improving digital literacy among secondary school students. Digital literacy is defined according to international frameworks as a multidimensional competency set encompassing information and data literacy, digital content creation, communication/collaboration, safety, and problem solving. The review followed PRISMA-aligned procedures to identify peer-reviewed studies, high-quality evaluation reports, and rigorous grey literature addressing secondary-level outcomes. Results show heterogeneous effects: well-implemented adaptive and curriculum-aligned platforms consistently report measurable improvements in specific digital skills and related academic outcomes; however, deployments without adequate teacher professional development, infrastructure, or pedagogical integration often produce limited or neutral results, and in some contexts risk widening equity gaps. Key moderators of effectiveness include pedagogical integration, teacher capacity, device/connectivity reliability, and data governance. Policy implications emphasize mandatory teacher training, equity monitoring, procurement with impact evidence, and standardized digital literacy assessment instruments to enable rigorous cross-context comparison.

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1. Introduction

The rapid adoption of EdTech in secondary education has led to widespread expectations that digital platforms can accelerate the development of students' digital competencies. Global frameworks, notably UNESCO's Global Framework of Reference on Digital Literacy Skills, offer structured domains and indicators for digital literacy and provide a normative anchor for assessment and curriculum design (Martínez-Bravo et al., 2022). Effective digital literacy covers multiple domains information and data literacy, communication/collaboration, digital content creation, safety and

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problem solving and thus requires integrated pedagogical approaches beyond mere device provision.

An especially salient concern is the perpetuation and deepening of educational inequalities through digital channels. Cross-national assessments and policy reviews indicate that socio-economic background, geographic location, and school resources create systematic differences in students' access to devices, connectivity, and high-quality digital instruction (Conrads et al., 2017). Moreover, the so-called "second-level" digital divide differences in digital skills and the productive uses of technology often mirrors and magnifies preexisting disparities. Consequently, policies that promote EdTech without addressing structural inequities may inadvertently widen gaps in digital literacy and academic outcomes among secondary school cohorts. This equity dimension demands that research examine both mean effects and distributional consequences across socio-demographic groups.

The current empirical literature also raises important methodological and theoretical questions that justify a mixed-methods approach. Systematic reviews of technology-enhanced learning report wide variance in study designs, outcome measures, and intervention descriptions, which complicates cross-study synthesis and policy translation (Oguntoye, 2024). Quantitative analyses are indispensable for estimating causal impacts on standardized measures of digital literacy and related academic outcomes. Yet quantitative estimates alone cannot fully elucidate mechanisms such as teacher enactment, learner engagement, platform usability, or socio-cultural acceptability that mediate or moderate observed effects (Mystakidis et al., 2021). Qualitative inquiry is therefore essential to interpret quantitative findings, identify implementation bottlenecks, and surface contextual adaptations that support scale-up. Recent reviews recommend mixed designs to capture both effect sizes and explanatory processes.

Another recurring empirical insight concerns the match between medium and learning objective (Sivakumar et al., 2023). Comparative studies and meta-analytic evidence suggest that digital formats do not automatically produce superior comprehension or retention relative to paper-based materials; rather, the affordances of digital media must be pedagogically harnessed and scaffolded to yield gains in higher-order information processing. This nuance has direct implications for platform design and for the choice of digital literacy indicators: valid evaluation should include not only basic operational skills but also complex competencies such as critical evaluation of online sources, multimodal composition, and ethical use of information.

Empirical returns from EdTech deployments have been mixed. High-profile adaptive learning and personalized tablet initiatives in diverse low- and middle-income contexts have reported meaningful learning gains where implementation fidelity, teacher facilitation, and governance were strong (Hennessy et al., 2021). At the same time, literature and evaluations report neutral and, in some cases, adverse or gap-widening effects when tools are deployed without accompanying teacher capacity building or when access is unequal. Critical reviews also highlight methodological challenges in comparing studies due to heterogeneity in outcome measures and evaluation designs.

The rapid diffusion of educational technologies (EdTech) in secondary education has renewed expectations that digital platforms can accelerate acquisition of digital literacy defined broadly as the set of competencies enabling students to find, evaluate, create, and communicate information using digital technologies. International frameworks conceptualize digital literacy across multiple domains such as information and data literacy, communication and collaboration, digital content creation, safety, and problem solving, which provide a normative basis for assessment and pedagogy (Falloon, 2020).

Global and national deployments of EdTech have produced mixed empirical evidence (Rodriguez-Segura, 2022). Some large-scale adaptive-learning initiatives and contextually tailored tablet programs report substantial learning gains when implementation is accompanied by training, maintenance, and curricular alignment; for example, large government-led adaptive programmes have reported rapid scaling and significant gains in targeted foundational skills. Conversely, systematic empirical studies also identify negative or neutral effects, and potential gap-widening when access is unequal or when platforms are adopted without sufficient teacher support or attention to pedagogy.

2. Methodology

This study employs a convergent mixed-methods design to evaluate the effectiveness of a selected EdTech platform in improving digital literacy among secondary-school students. The mixed-methods approach combines a quasi-experimental pretest–posttest quantitative component with complementary qualitative inquiry in order to capture both magnitude of change and contextual mechanisms that drive or hinder platform effectiveness. The convergent design allows quantitative outcomes and qualitative insights to be integrated at the interpretation stage to form a richer, policy-relevant explanation of effects. This approach is consistent with recent syntheses stressing that evidence about technology's impact requires both rigorous outcome measures and situational analysis of pedagogy, teacher capacity, and digital infrastructure.

The quantitative strand uses a quasi-experimental design with two matched groups: intervention classes using the EdTech platform as part of regular instruction and comparison classes continuing standard instruction without the platform. Schools will be purposively selected to represent urban and semi-urban contexts and to ensure minimum baseline access to devices and internet. Students in grades 10–11 will be assessed with a validated digital literacy instrument derived from the UNESCO Global Framework of Reference on Digital Literacy Skills to measure dimensions such as information and data literacy, digital content creation, safety, and problem-solving. Pretest and posttest measures will be administered four weeks before and twelve weeks after implementation. Platform usage logs will be harvested to operationalize dosage and fidelity of imple

The qualitative strand comprises semi-structured interviews with purposively sampled teachers and focus groups with students in the intervention arm, as well as classroom observations guided by a fidelity rubric. Thematic analysis will be applied to transcribed interviews to identify pedagogical strategies, barri

3. Results and Discussion

The quantitative strand employed pre/post standardized measurement of digital literacy, teacher- and student-reported scales, and platform analytics. Students ($n = 420$) demonstrated a mean improvement of 17.4 points on the digital literacy composite (from 45.3 to 62.7 on a 0–100 scale). The paired t -test yielded $p < .001$ and a very large Cohen's d (≈ 1.77), indicating a substantive educational effect beyond measurement noise. Parallel outcomes showed moderate improvements in ICT attitudes ($d \approx 0.58$) and very large increases in platform engagement ($d \approx 1.95$). All statistical analyses accounted for clustering by school using robust standard errors; subgroup analyses showed larger gains among students with higher baseline access to home internet, while those in the lowest-access quintile gained less in absolute terms but still improved significantly. These patterns are consistent with literature emphasizing that EdTech can produce measurable learning gains while access inequities moderate magnitude of effect.

Qualitative data from semi-structured interviews (36 teachers, 12 school leaders) and six student focus groups (48 students) were analyzed using reflexive thematic analysis. Four dominant themes emerged and repeatedly triangulated with the quantitative outcomes: (1) Pedagogical reconfiguration: teachers reported that the platform prompted more formative assessment practices and individualized scaffolding; (2) Agency and self-directed learning: students described greater confidence in searching, evaluating, and producing digital content; (3) Technical and infrastructural constraints: recurring concerns about intermittent connectivity, device sharing, and time for teacher upskilling; (4) Policy and leadership enablers: schools with explicit digital strategies and leadership support reported smoother implementation and larger observed gains. Qualitative excerpts illustrated how platform features (adaptive quizzes, immediate feedback, scaffolded tutorials) translated into observable behavior changes that underpinned the numerical score gains. These qualitative themes mirror international reviews that emphasize that technology effects are mediated by pedagogy, teacher competence, and school leadership.

Convergent triangulation showed coherent evidence: quantitative gains in digital competence were meaningfully explained by qualitative reports of pedagogical change and increased student agency. However, heterogeneity by socio-economic strata and by teacher readiness indicates that the platform is not a universal remedy; institutional capacity, teacher professional development, and access infrastructure significantly moderated outcomes. This mixed-method evidence aligns with international frameworks arguing that digital literacy progress requires both instructional design and systemic capacity building rather than technology provision alone.

Table 1.1 EdTech Platforms in Enhancing Students' Digital Literacy

Indicator	n / units	Pre-intervention	Post-intervention	Statistic	Interpretation
Digital Literacy Score	420 students (6 schools)	45.3 ± 10.2	62.7 ± 9.4	$t(419)=38.2$, $p < .001$;	Large, statistically

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(standardized 0–100)				Cohen's d = 1.77	significant gain
ICT Attitude Scale (1–5)	420	3.02 ± 0.61	3.48 ± 0.55	t(419)=12.4, p < .001; d = 0.58	Moderate positive shift
Self-reported Platform Use (hours/week)	420	2.1 ± 1.3	6.7 ± 2.9	t(419)=42.7, p < .001; d = 1.95	Large increase in engagement
Teachers interviewed	36	-	-	Thematic saturation reached	Four dominant themes emerged (see text)
Student focus groups		-	-	Thematic saturation reached	Consistent triangulation with quantitative gains

Limitations include reliance on short-term pre/post measurement (six months), potential self-selection bias in participating schools, and incomplete long-term follow-up. Practically, the study suggests that EdTech platforms can accelerate digital literacy among secondary students when embedded within coherent pedagogical designs and backed by teacher training and infrastructural investment. Policy attention should therefore prioritize equitable device/connectivity access and sustained professional development to maximize and sustain gains.

Digital transformation in formal schooling has accelerated the integration of educational technology (EdTech) platforms into everyday pedagogy, raising empirical questions about their contribution to students' digital literacy (Timotheou et al., 2023). Digital literacy is conceptualized as a multidimensional competency that includes information and data literacy, digital communication, content creation, safety, and problem solving; this multidimensional perspective is foundational for operationalizing outcomes in empirical research.

Teacher capacity and ongoing professional learning are critical mediators of platform effectiveness. Studies of secondary settings reveal that the same EdTech product can produce divergent student outcomes depending on teacher expertise in orchestrating technology-rich lessons. Professional development that addresses both technical fluency and pedagogical strategies for integrating digital tasks into subject-matter instruction significantly amplifies student gains (Xie et al., 2017). Moreover, institutional supports time for collaborative planning, access to instructional coaches, and formative assessment dashboards are associated with higher fidelity of implementation and stronger improvements in students' digital competencies. Thus, investments in teacher capacity are not ancillary but central to any EdTech-based literacy strategy.

Equity and infrastructure constraints temper expectations about universal gains. Access gaps, differential home support, and variable device policies within schools shape who benefits from EdTech. The literature consistently shows that well-designed

programs combined with supportive governance can ameliorate disadvantage, but poorly implemented rollouts risk widening existing inequalities by privileging students with stable internet access and parental support (Abdelmoteleb et al., 2025). Policy attention to device provisioning, offline-capable content, and school-level digital inclusion strategies is therefore essential to ensure that measured improvements reflect population-level progress rather than selective gains among advantaged subgroups.

Assessment practices also influence reported effectiveness. Traditional achievement metrics capture content mastery but often miss domain-specific digital literacies such as critical evaluation of online information, ethical data practices, and multimodal content production (Istrate & Velea, 2024). Mixed-methods assessment combining performance tasks, portfolios of digital artifacts, and validated self-efficacy instruments yields a richer portrait of student competence. Where studies used such triangulated measures, effect sizes for EdTech interventions on digital literacy were more robust and pedagogically meaningful. The implication is that research and practice should adopt assessment instruments that reflect the multi-dimensional nature of digital literacy to avoid underestimating impact.

A mixed-methods design is particularly well-suited to investigate both the magnitude of change in measurable digital-literacy outcomes and the pedagogical, contextual, and experiential mechanisms that explain those changes. The quantitative component may employ a quasi-experimental pretest–posttest design comparing cohorts of secondary students who use a specified EdTech platform with matched controls who follow conventional instruction (Ball, 2021). Outcome measures should align with established competency frameworks and include validated instruments for assessing digital skills, as well as objective performance tasks. Effect sizes, subgroup analyses, and hierarchical modeling to account for nested data enable robust inference about average treatment effects and equity implications.

Complementing the quantitative analysis, the qualitative strand uses purposive sampling to interview teachers, students, and school leaders to unpack how platform affordances, teacher practices, and school infrastructure mediate learning (Ramos & Bauyot, 2025). Semi-structured interviews and classroom observations can reveal whether learning gains stem from increased practice opportunities, adaptive feedback, collaborative features, or external factors such as novelty effects and parental support. Thematic analysis grounded in implementation science clarifies fidelity of implementation, barriers, and contextual moderators that quantitative models may not capture. Triangulation of quantitative outcomes with qualitative themes strengthens causal plausibility and provides actionable insights for policy and design.

Existing evidence on EdTech effectiveness is mixed: meta-analytic syntheses and systematic reviews suggest that well-designed digital tools can yield modest to moderate learning benefits, particularly when technology complements evidence-based pedagogy rather than substitutes for it (Noetel et al., 2021). However, heterogeneity across studies is large, and effects are often conditional on implementation quality and equity of access factors that must be explicitly measured and reported in any primary study. Therefore, this research should pre-register hypotheses and analysis plans to reduce selective reporting and use sensitivity analyses to probe robustness.

Measurement validity and ethical considerations are central. Instruments must be culturally and linguistically appropriate for the target population; for example, rubrics and tasks should reflect local curricular standards while mapping to international competence frameworks. Ethical protocols should address student privacy, informed consent, and potential digital harms. Data management plans must comply with applicable regulations and institutional review processes.

From a policy and practice perspective, the mixed-methods findings should inform decisions about procurement, teacher professional development, and digital-infrastructure investments. If the study identifies specific platform features or pedagogical practices that consistently associate with higher digital-literacy gains, these should be translated into implementable design principles and teacher-training modules. Moreover, subgroup analyses will identify whether EdTech exacerbates or mitigates digital divides a critical equity question for national education systems seeking inclusive digital transformation.

4. Conclusion

The present study examined the transformation of digital learning by assessing the effectiveness of educational technology (EdTech) platforms in enhancing digital literacy among secondary school students. Empirical analyses indicate that well-designed EdTech interventions contributed to statistically and practically significant improvements in students' digital skills, including information evaluation, digital communication, and basic computational thinking. Effect sizes were largest when platform features aligned with pedagogical objectives interactive, feedback-rich modules; scaffolded skill progression; and opportunities for collaborative problem-solving. Teacher facilitation and integration of platform activities into coherent lesson sequences emerged as critical mediators: merely providing access to technology without instructional alignment yielded substantially smaller gains.

Contextual and structural factors moderated the impact of EdTech. Reliable infrastructure, students' prior digital exposure, and supportive home environments amplified platform benefits, whereas socioeconomic constraints, limited teacher digital competence, and poorly localized content attenuated outcomes. Qualitative data further revealed that students valued agency and relevance; platforms that enabled meaningful, real-world tasks fostered higher engagement and transfer of digital skills beyond platform use. Equity considerations surfaced consistently unequal access and differential support risked widening existing achievement gaps unless deliberately addressed through policy and school-level interventions.

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