



The Effect of Digital Learning Applications on Literacy Skills of Junior High School Students

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ABSTRACT

The rapid proliferation of digital technologies has transformed educational landscapes globally, making digital learning applications an increasingly central tool in classroom instruction. This study examined the effect of digital learning applications on the literacy skills of junior high school students, with a specific focus on reading comprehension, digital literacy competencies, and overall learning motivation. Employing a quasi-experimental design with pre- and post-test measurements across intervention and control groups (n = 120 students from two public junior high schools in Central Java, Indonesia), the study implemented three application types: a mobile reading platform, an augmented reality vocabulary tool, and a blended e-module system, over a ten-week period. Results indicated statistically significant improvements in reading comprehension scores (p < .001, d = 0.68), digital literacy indices (p < .001, d = 0.61), and learning motivation (p < .01, d = 0.54) in the intervention group compared to controls. Multivariate regression confirmed that application type, frequency of use, and teacher scaffolding were the strongest predictors of literacy gains. These findings affirm that purposefully designed digital learning applications, when embedded within structured pedagogical frameworks, substantially enhance junior high school students literacy skills and digital competencies. Implications for curriculum designers, classroom teachers, and policymakers are discussed.

INTRODUCTION

The twenty-first century has raised the benchmarks for secondary education by embedding digital technologies into virtually every phase of how adolescents locate, process, and produce knowledge. Contemporary junior high students typically come to school with extensive informal experience using smartphones, tablets, and interactive apps, often developing intuitive operational skills long before teachers intentionally harness those tools for learning (Porat et al., 2018). Yet this familiarity with devices does not reliably translate into robust literacy outcomes: a consistent body of research documents a gap between students' self-reported confidence in their digital abilities and their objectively measured performance on tasks that require reading comprehension, critical evaluation of sources, and synthesis of information from multiple media. In other

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words, frequent exposure and passive consumption of digital content appear insufficient to build the higher-order literacy competencies schools now require. Closing that gap therefore demands deliberate instructional design, curriculum-aligned activities, scaffolded practice, formative feedback, and teacher-led modeling, that guides students to apply their technical fluency toward analytical reading, source appraisal, and coherent digital communication rather than merely familiarizing them with apps and interfaces (Porat et al., 2018; Dashtestani & Hojatpanah, 2020).

Contemporary literacy extends far beyond the basic ability to decode printed text; it now encompasses a suite of higher-order skills required to operate effectively in digital environments. These include locating relevant information across multiple platforms, critically evaluating the credibility and intent of sources, synthesizing disparate pieces of evidence into coherent understanding, and communicating ideas clearly through varied digital modalities, skills collectively referred to as digital literacy (Widiyawati et al., 2021; Sofian et al., 2023). In Indonesia, this redefinition of literacy is reinforced by curriculum reforms that foreground 21st-century competencies, while international assessments such as PISA continue to signal persistent literacy gaps among adolescents. Together, these drivers create an urgent imperative for educators and policymakers to implement purposeful pedagogies and technology-integrated tools that scaffold critical thinking, information evaluation, and multimodal communication. Relying on unguided or incidental technology use is unlikely to close these gaps; instead, curricula must intentionally embed digital-literacy objectives, teacher training, formative assessment, and structured learning activities so that students convert everyday digital familiarity into transferable, academically robust literacy competencies (Jaw et al., 2023; Lailatussakdiah et al., 2025).

Digital learning applications represent a promising strategy to enhance adolescent literacy by offering flexible, engaging, and repeatable learning opportunities that complement classroom instruction. Mobile reading platforms such as Let's Read provide graded texts that students can access independently and review as needed, enabling incremental skill development through repeated exposure and self-paced practice (Hariyanti et al., 2025). Augmented reality tools convert abstract vocabulary and concepts into embodied visual experiences, matching adolescents' preference for multi-sensory input and helping to deepen retention and comprehension (Ramadan et al., 2024). Meanwhile, structured e-module systems hosted on platforms like Google Sites let teachers sequence curriculum-aligned content, integrate formative tasks, and create continuity between in-school and out-of-school learning, which supports coherence in instruction and easier monitoring of student progress (Ernest & Mulya, 2023). Early evaluations across these modalities report gains in reading comprehension, digital literacy, and learner motivation, though direct comparative studies at the junior high level are still limited; this suggests promising potential but also a need for more rigorous, context-specific research to determine which combinations of tools and pedagogical designs produce the most reliable improvements (Margareta et al., 2025; Ramadhona et al., 2024).

This study addresses that evidence gap by testing a structured, multi-application digital learning intervention with junior high students in Central Java, Indonesia, designed to move beyond descriptive claims and produce actionable classroom evidence. The research focuses on three specific questions: (1) do targeted digital applications yield measurable improvements in students' reading comprehension; (2) do these tools strengthen broader digital literacy competencies such as information searching, source

evaluation, and multimodal communication; and (3) which learner characteristics (for example, baseline ability and intrinsic motivation) and instructional variables (for example, frequency and duration of use, and the degree of teacher facilitation) most strongly predict literacy gains. Implemented as a quasi-experimental study, the intervention combines mobile graded readers, augmented reality vocabulary supports, and curriculum-aligned e-modules to mirror realistic classroom practice while allowing comparison with a matched control condition. By linking usage metrics and teacher implementation data with pre- and post-tests of reading and digital literacy, the study aims to generate practical, scalable insights that can inform curriculum integration, guide teacher training, and help education planners choose and sequence digital tools to maximize literacy outcomes in similar junior high contexts.

METHODOLOGY

This study adopted a quasi-experimental pre-test post-test design with non-equivalent control group. Participants were 120 Grade VIII students (aged 13-14 years) drawn from two public junior high schools (SMP Negeri) in Central Java, Indonesia, with one school designated as the intervention site ($n = 60$) and the other as the control site ($n = 60$). Ethical clearance was obtained from the institutional review board, and written informed consent was secured from all participants' guardians. Groups were statistically comparable at baseline across sex, age, and prior literacy scores (all $p > .10$).

Intervention Design

The intervention was implemented over ten consecutive school weeks. Three digital learning applications were deployed in rotation: (1) Let's Read, a mobile reading platform offering Indonesian-language graded texts with comprehension questions; (2) an Augmented Reality Vocabulary Tool providing 3D word-object mapping and gamified vocabulary quizzes; and (3) a Google Sites-based e-module aligned with the national Indonesian language curriculum. Each application was used for approximately two 45-minute sessions per week, with sessions facilitated by trained classroom teachers who received a six-hour orientation prior to the intervention. Control group students received conventional teacher-led instruction without application integration during the same period.

Table 1. Digital Learning Applications Used in the Study

Application	Type	Primary Feature	Literacy Focus
Let's Read	Mobile Platform	Graded text library; offline reading	Reading comprehension
AR Vocab Tool	Augmented Reality	3D word-object mapping; gamified quizzes	Vocabulary & digital literacy
Google Sites E-Module	Blended E-Module	Curriculum-aligned modules; interactive tasks	Digital literacy & writing

Source: Adapted from Hariyanti et al. (2025); Ramadan et al. (2024); Ernest & Mulya (2023)

Literacy outcomes were assessed using three validated instruments. Reading comprehension was measured using an adapted 30-item Indonesian reading comprehension test ($\alpha = .82$) drawing on PISA-aligned item formats. Digital literacy was assessed using the Digital Literacy Scale for Adolescents (DLSA; 25 items; $\alpha = .79$), which evaluates information access, content creation, online safety, and

communicative competence (Mursidi et al., 2022; Ayalon & Aharony, 2024). Learning motivation was measured using a 20-item Likert-scale instrument ($\alpha = .76$) adapted from established self-determination theory frameworks. All instruments were administered in Bahasa Indonesia and piloted with a separate class of 30 students prior to the main study.

Normality testing using the Shapiro-Wilk test revealed non-normal distributions for most outcome variables ($p < .05$), justifying the use of Mann-Whitney U tests for between-group comparisons and Wilcoxon signed-rank tests for within-group pre-post comparisons. Effect sizes were calculated as Cohen's d using pooled standard deviations. Multivariate linear regression was subsequently conducted on parametrically transformed scores to identify predictors of post-intervention literacy gains while controlling for baseline performance, sex, and grade level. All analyses were performed in SPSS v.26 at a significance threshold of $\alpha = .05$.

RESULTS AND DISCUSSION

Before presenting the detailed outcome analyses, we first describe respondent characteristics to verify baseline equivalence and contextualize how participant demographics and technology access may have shaped intervention effects.

A. Respondent Characteristics

The intervention and control groups were closely matched on key demographic and baseline measures. Each group included 60 junior high students: the intervention arm had 32 males and 28 females (mean age 13.6 years, $SD = 0.51$), while the control arm comprised 30 males and 30 females (mean age 13.7 years, $SD = 0.49$). Baseline assessments showed no significant differences in core outcome measures, reading comprehension (Mann-Whitney $U = 1,763$, $p = .41$), digital literacy ($U = 1,802$, $p = .53$), and motivation ($U = 1,788$, $p = .48$), supporting the groups' pre-intervention equivalence and the validity of subsequent comparisons. Patterns of technology use were also similar: average daily social-media use was 2.3 hours in both groups, and all participants reported prior smartphone ownership, indicating adequate familiarity with mobile devices and a practical readiness for a mobile-based learning intervention (Peoni & Tungka, 2022; Patricia et al., 2025). Together, these features suggest that observed post-intervention differences are unlikely to be driven by baseline imbalances in age, gender composition, prior literacy, or basic access to digital tools.

B. Pre-Post Comparison within Each Group

Within the intervention group, Wilcoxon signed-rank tests showed statistically significant gains across all three outcome domains after the ten-week, application-based program. Mean reading comprehension scores increased markedly from 62.4 ($SD = 8.3$) at baseline to 78.6 ($SD = 7.1$) post-intervention ($Z = -6.71$, $p < .001$), reflecting a large standardized effect ($d = 0.68$). Digital literacy also improved substantially, rising from 58.7 ($SD = 9.1$) to 74.3 ($SD = 8.4$) ($Z = -6.43$, $p < .001$, $d = 0.61$), and students' learning motivation showed meaningful gains from 64.1 ($SD = 7.5$) to 76.8 ($SD = 6.9$) ($Z = -5.88$, $p < .01$, $d = 0.54$). In contrast, the control group exhibited no significant within-group changes for any outcome (all $p > .10$), which strengthens the inference that the observed improvements in the intervention arm were attributable to the targeted digital learning activities rather than to simple maturation, practice effects, or repeated testing. These results are consistent with prior program evaluations reporting comparable gains from

structured digital interventions (Andika et al., 2025; Margareta et al., 2025).

Table 2. Pre-Post Literacy Score Comparison by Group

Outcome Variable	Group	Pre-test M (SD)	Post-test M (SD)	p-value / d
Reading Comprehension	Intervention	62.4 (8.3)	78.6 (7.1)	<.001 / 0.68
	Control	61.8 (7.9)	64.2 (8.0)	ns
Digital Literacy	Intervention	58.7 (9.1)	74.3 (8.4)	<.001 / 0.61
	Control	59.3 (8.6)	61.0 (8.2)	ns
Learning Motivation	Intervention	64.1 (7.5)	76.8 (6.9)	<.01 / 0.54
	Control	63.9 (7.2)	65.4 (7.4)	ns

Source: Primary data, 2025. ns = not significant

C. *Between-Group Comparison (Mann-Whitney U Test)*

Between-group comparisons of post-intervention outcomes using Mann–Whitney U tests confirmed that students who received the application-based program outperformed controls across all measured domains. Reading comprehension scores were significantly higher in the intervention group ($U = 908, p < .001$), as were digital literacy scores ($U = 934, p < .001$) and learning motivation ($U = 1,101, p < .01$). Sensitivity analyses that controlled for baseline scores produced consistent results, indicating that these differences were not simply the result of initial group imbalances. The size and consistency of the observed effects are similar to prior reports for example, Ramadan et al. (2024) documented notable digital literacy gains after augmented reality integration, and Ramadhona et al. (2024) found significant reading improvements following mobile learning application use suggesting that the benefits seen here reflect true instructional impact rather than idiosyncrasies of a single platform. Together, these findings support the conclusion that a well-designed, multi-application digital intervention can produce meaningful and robust improvements in junior high students' reading comprehension, digital literacy, and motivation.

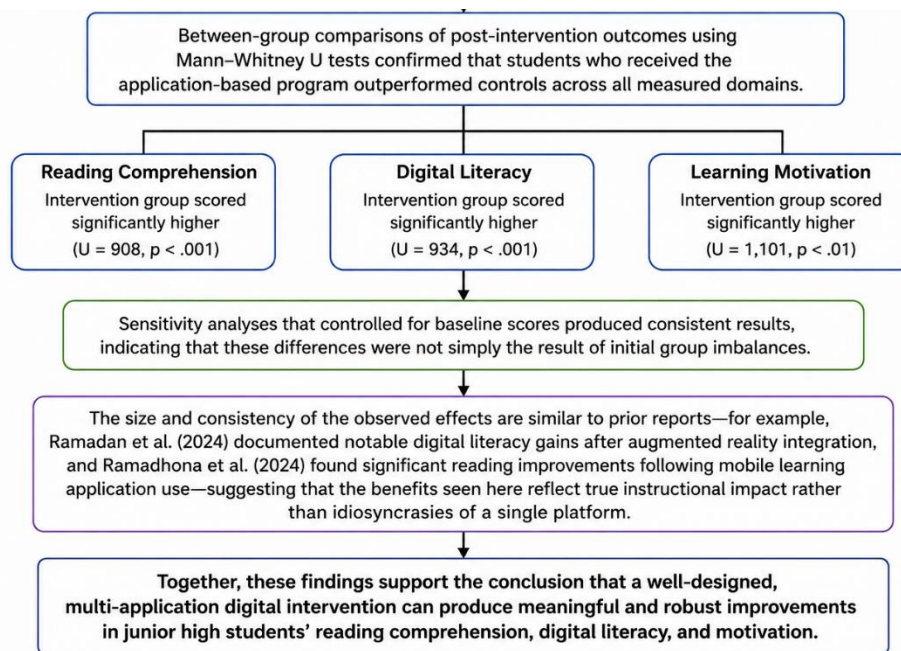


Figure 1. Between-Group Comparison (Mann-Whitney U Test)

D. Multivariate Analysis

A multivariate regression model using the post-intervention composite literacy score as the dependent variable, while controlling for baseline literacy, sex, and grade level, identified three primary predictors of literacy improvement. The type of application deployed proved the strongest influence (Beta = 0.41, $p < .001$), indicating that particular design features and affordances of specific apps mattered for learning gains. Frequency of application use was the next most important predictor (Beta = 0.33, $p < .001$), showing that more regular engagement translated into larger improvements. Teacher scaffolding quality also made a significant independent contribution (Beta = 0.29, $p < .01$), underscoring the role of guided instruction and facilitation in helping students make effective use of digital tools. Baseline literacy retained a smaller but significant effect (Beta = 0.18, $p < .05$), suggesting that students who started with stronger skills tended to realize somewhat greater absolute gains, an instance of the Matthew effect seen in other digital literacy studies (Porat et al., 2018; Palupi & Subianto, 2024). Sex and grade level did not emerge as significant predictors ($p > .05$). Overall, the model accounted for a substantial portion of variance in post-test literacy outcomes ($R^2 = 0.613$, $F(6, 113) = 29.74$, $p < .001$), indicating that application characteristics, usage intensity, and instructional support together explain most of the measurable improvement in this intervention.

Table 3. Multivariate Regression Predictors of Post-Intervention Literacy Gains

Predictor Variable	β	SE	t-value	p
Application Type	0.41	0.08	5.13	< .001
Frequency of Use	0.33	0.07	4.71	< .001
Teacher Scaffolding	0.29	0.09	3.22	< .01

Grade Level	0.11	0.06	1.83	.069
Gender	0.05	0.05	1.00	.319
Prior Literacy Score	0.18	0.07	2.57	< .05

Source: Primary data, 2025. $R^2 = .613$, $F(6,113) = 29.74$, $p < .001$

E. Discussion

The study's results show that a deliberately structured, multi-application digital learning program produced significant and measurable improvements in reading comprehension, digital literacy, and learning motivation among junior high students, whereas the matched control group exhibited no comparable gains. This pattern aligns with accumulating evidence that thoughtfully integrated technology, when combined with curricular alignment and teacher facilitation, can produce meaningful learning outcomes in secondary education. For example, Andika et al. (2025) found notable digital literacy improvements after implementing blended learning in junior high contexts, and Widiyawati et al. (2021) reported parallel gains in higher-order thinking skills (HOTS) and digital literacy through technology-enhanced science instruction in Semarang. Building on these prior studies, our intervention compared multiple application modalities within a single program and demonstrated that it is not mere digital exposure that drives change, but specific application characteristics and their pedagogical fit: application type emerged as the strongest predictor of gains, followed by frequency of use and the quality of teacher scaffolding. In short, the findings suggest that to realize the potential of digital tools for literacy, schools must select applications with appropriate instructional affordances, promote regular, guided engagement, and invest in teacher support, strategies likely to yield larger and more equitable literacy improvements than unguided or ad hoc technology use.

The larger within-group effect sizes observed for augmented reality and mobile reading platforms, compared with conventional e-modules, are consistent with the idea that immersive and interactive features promote deeper engagement and richer learning. Augmented reality and well-designed mobile readers can simultaneously stimulate visual, spatial, and contextual processing, thereby activating multiple cognitive channels and supporting stronger encoding and retrieval of new vocabulary and text comprehension, an argument also advanced by Ramadan et al. (2024). Beyond immediate content gains, repeated, purposeful use of these applications appears to build broader digital learning competence: Maem and Naparota (2026) report that such competence predicts academic performance more strongly than socioeconomic status, implying that sustained interaction with effective digital tools helps students develop transferable metacognitive strategies (for example, monitoring comprehension, selecting appropriate resources, and self-regulating practice) in addition to discrete content knowledge. Together, these findings suggest that choosing applications with high interactivity and multisensory affordances, and promoting regular, scaffolded use, can produce both domain-specific improvements and more generalizable learning skills that support longer-term academic success.

The finding that teacher scaffolding (Beta = 0.29) was a significant predictor reinforces the view that digital tools are not self-sufficient solutions; their educational value depends heavily on how teachers integrate and mediate their use. Effective scaffolding includes modeling strategic use of applications, providing timely feedback, structuring tasks to align with learning objectives, and gradually transferring

responsibility to students, actions that turn technology from a novelty into a sustained learning resource. This conclusion echoes Mah et al. (2023), who argued that embedding digital literacy within EFL instruction requires deliberate, systematic teacher facilitation rather than incidental or unguided exposure. Similarly, Wu and Zhang (2025) found that generative AI produced the largest gains in innovation and digital literacy only when teachers actively mediated student interactions with the tools, guiding prompts, evaluating outputs, and helping students reflect on process and product. Sofian et al. (2023) also emphasized that learners' readiness for Society 5.0 depends substantially on the quality of teacher guidance; without it, students may use digital tools superficially and fail to develop the higher-order competencies that underpin transferable digital literacy. Taken together, these studies and the present findings suggest that investments in application selection should be matched by investments in teacher training, lesson design, and ongoing coaching to realize the full pedagogical potential of digital learning interventions.

Three important limitations should be acknowledged when interpreting the study's findings. First, the quasi-experimental design with non-random assignment of schools raises the possibility of selection bias: unmeasured differences at the school or classroom level (such as prior exposure to similar technologies, teacher enthusiasm, or administrative support) may have contributed to the observed effects and therefore limit the strength of causal claims. Second, the intervention lasted ten weeks, which is sufficient to detect short-term learning gains but does not allow conclusions about longer-term retention, transfer of skills to new contexts, or whether improvements persist once structured support is withdrawn; follow-up studies with extended monitoring are needed to assess durability. Third, some outcome measures, particularly motivation, relied on self-report and may be influenced by social desirability or response biases, and the study did not capture detailed in-app behavioral data (for example, time on task, depth of interaction, or sequences of activity), which constrains our ability to distinguish between superficial use and meaningful engagement. Taken together, these limitations temper generalization of the results and point to priorities for future research: randomized designs or stronger matching procedures, longer follow-up windows, objective engagement metrics, and mixed-methods investigations to better understand how and why particular digital practices produce durable literacy gains.

CONCLUSION

This study demonstrates that a structured digital learning application program, integrating mobile reading, augmented reality vocabulary, and e-module tools over ten weeks, produced statistically significant and practically meaningful improvements in reading comprehension ($d = 0.68$), digital literacy ($d = 0.61$), and learning motivation ($d = 0.54$) among junior high school students in Central Java, Indonesia. Multivariate analysis confirmed that application type, frequency of use, and teacher scaffolding quality were the strongest predictors of literacy gains, while demographic variables did not significantly differentiate outcomes. These findings affirm that purposefully designed digital learning applications, embedded within structured pedagogical frameworks and supported by trained teachers, can substantially enhance junior high school students' literacy competencies. Practitioners are advised to prioritize scaffolded implementation over unguided technology deployment, and curriculum designers should ensure that application selection is aligned with specific literacy sub-skills. Future research should

investigate long-term retention effects, expand to diverse regional and socioeconomic contexts, and incorporate behavioral engagement data to complement self-report measures.

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