



Turning Pages Intelligently: AI Pop-Up Book as an Innovative Medium to Enhance English Reading Comprehension Among Elementary EFL Students

Evi Puspita Sari¹, Semi Sukarni², Ismawati Ike Nugraeni³

^{1,2,3}English Language Education, Universitas Muhammadiyah Purworejo, Indonesia

Article Info	Abstract
Received: 2026-05-31 Revised: 2026-06-29 Accepted: 2026-06-30 Keywords: AI Pop-Up Book; English Reading Comprehension; Elementary EFL; Pre-Experimental Design; Instructional Media. DOI: 10.24256/ideas.v14i1.10930 Corresponding Author: Evi Puspita Sari viisari292@gmail.com English Language Education, Universitas Muhammadiyah Purworejo, Indonesia	<i>Can an AI-powered pop-up book genuinely move the needle on reading comprehension for young EFL learners? This study examined that question through a pre-experimental one-group pretest-posttest design involving 21 fifth-grade students at SD Negeri Sidomulyo, Indonesia. The AI Pop-Up Book media — combining interactive three-dimensional visuals with adaptive AI feedback — was implemented across structured reading sessions, with learning outcomes measured via a 15-item comprehension test and analyzed using Paired Samples t-Test and Normalized Gain (N-Gain). Results revealed a statistically significant improvement from a mean pretest score of 68.33 to a posttest score of 76.43 ($t(20) = 3.179$, $p = 0.005$), with a concurrent reduction in score variability suggesting more equitable learning gains across the class. While the group mean N-Gain of 0.072 appears modest, it is substantially skewed by a single ceiling-effect outlier; when excluded, over half the students (52.38%) achieved moderate to high individual gains. These findings demonstrate that AI Pop-Up Book media holds genuine promise for elementary EFL reading instruction, provided it is supported by adequate teacher scaffolding, digital literacy preparation, and extended implementation time.</i>

1. Introduction

Reading comprehension occupies a central position in language education, as it underpins learners' capacity to interpret, critically engage with, and derive meaning from written discourse (Li & Gan, 2022). Despite its foundational importance, a persistent and well-documented comprehension gap continues to characterize English as a Foreign Language (EFL) classroom worldwide, particularly at the elementary level where cognitive and linguistic resources are still developing. Students in such contexts frequently encounter texts with insufficient scaffolding, limited exposure to authentic reading materials, and instructional practices that prioritize rote decoding over deeper meaning construction (Hidayat, 2024).

These systemic shortcomings have intensified scholarly and pedagogical interest in Artificial Intelligence (AI) as a transformative force in literacy instruction. Unlike static instructional tools, AI-powered platforms can dynamically personalize learning pathways, monitor comprehension in real time, and adjust task difficulty in response to individual learner performance — capabilities that directly address the structural limitations of conventional EFL reading instruction (Kristiawan et al., 2024; Lin et al., 2025). The accumulating empirical evidence positions purposeful AI integration not merely as a technological enhancement, but as a pedagogically grounded response to the global reading comprehension deficit.

Among the populations most vulnerable to reading comprehension difficulties, elementary EFL learners occupy a uniquely challenging position: they must simultaneously construct literacy in their first language while navigating the additional cognitive and linguistic demands of reading in English (Kahn-Horwitz & Goldstein, 2023). Research on EFL reading literacy at the primary school level consistently identifies vocabulary knowledge, metacognitive strategy use, and reading motivation as the dominant predictors of comprehension success — yet these dimensions are systematically neglected in conventional classroom instruction, which continues to rely on transmission-based, text-only approaches ill-suited to the cognitive profiles of young learners (Li et al., 2023).

Bogaert et al. (2023) further demonstrated that a substantial proportion of elementary students have not internalized effective comprehension-monitoring strategies, leaving them ill-equipped to detect and repair comprehension failures. Compounding this instructional gap is the broader observation that many EFL classrooms depend on static printed materials that offer neither visual stimulation nor interactive engagement — a design that structurally conflicts with the multimodal learning preferences and shorter sustained-attention capacities characteristic of children aged 9–12 (Noori, 2025). These converging challenges make a compelling case for instructional media that is simultaneously interactive,

visually rich, and capable of providing responsive feedback tailored to individual learner needs.

Pop-up books have long been recognized as engaging visual media whose three-dimensional, interactive structure captures learners' attention and sustains motivation in reading activities (Sunarti et al., 2023). Recent technological convergence, however, has fundamentally expanded their instructional potential: contemporary AI-integrated pop-up books combine the tactile and visual affordances of traditional formats with adaptive digital features — including real-time comprehension feedback, dynamic difficulty adjustment, and personalized prompting — that respond to individual learner performance (Ferdianto et al., 2026; Maulana & Purwati, 2025). This integration is theoretically grounded in Mayer's (2009) Cognitive Theory of Multimedia Learning, which posits that the coordinated presentation of verbal, visual, and interactive channels deepens cognitive processing and promotes more durable comprehension construction than single-channel instruction.

Empirical support for this premise is emerging: Huda and Kiptiyah (2024) found that digital pop-up book formats produced significant improvements in both student engagement and learning outcomes, while Munajah et al. (2025) demonstrated that augmented reality-enhanced pop-up books meaningfully advanced early reading skills in Grade 1 students. Taken together, these findings suggest that AI Pop-Up Book media constitutes a theoretically coherent and empirically promising instructional intervention for elementary EFL reading comprehension.

Converging evidence from two independent research strands further reinforces the rationale for this intervention. Studies examining AI-assisted reading tools consistently report that students exposed to adaptive, AI-personalized instruction demonstrate significantly greater comprehension gains than their counterparts in conventional settings (Hidayat, 2024; Shafiee Rad, 2025). Shafiee Rad (2025) established that AI-mediated reading interventions not only improve comprehension scores but also foster self-regulated reading strategies — a metacognitive outcome with lasting implications beyond immediate test performance.

In parallel, research on pop-up book media documents robust improvements in students' reading engagement and skill acquisition compared to traditional printed instruction (Sunarti et al., 2023; Munajah et al., 2025). The theoretical synergy between these two paradigms is meaningful: AI-adaptive systems address the personalization deficit of static media, while the multimodal and interactive structure of pop-up formats provides the sensory engagement that purely text-based AI platforms lack. Their integration therefore holds the potential to produce instructional outcomes that neither approach could achieve in isolation.

Despite this theoretical and empirical momentum, a meaningful research gap persists. Existing studies have examined AI-based reading tools and pop-up book media in isolation, but their deliberate integration into a single instructional medium for elementary EFL reading comprehension remains underexplored (Kristiawan et al., 2024; Supriani et al., 2024). Studies that do address digital pop-up formats rarely incorporate AI-adaptive components, and AI reading research seldom exploits the multimodal affordances of interactive visual media.

Furthermore, investigations conducted within the Indonesian elementary EFL context are particularly scarce, despite the country's distinctive challenges of large mixed-ability classrooms, limited digital infrastructure, and local curriculum demands that shape how such media can realistically be implemented (Anggrasari & Dayu, 2022). This study responds to these gaps by pursuing two objectives: (1) to describe how AI Pop-Up Book media is implemented in English reading comprehension instruction for fifth-grade elementary EFL students, and (2) to determine whether this media produces a statistically significant improvement in students' reading comprehension scores.

2. Method

This study adopted a pre-experimental one-group pretest-posttest design, integrating quantitative measurement of learning outcomes with qualitative description of the intervention process (Creswell & Creswell, 2023). The population of this study was all fifth-grade students at SD Negeri Sidomulyo, comprising a single intact class. Because the population consisted of only one class, total sampling was applied, yielding a sample of 21 students (12 male, 9 females; aged 10–11) with no prior experience using AI Pop-Up Book media (Sugiyono, 2022). Data were collected through three instruments: (1) a written pretest and posttest, (2) structured classroom observation, and (3) school documentation.

The reading comprehension test consisted of 15 items — 10 multiple-choice and 5 short-answer essay questions — constructed around age-appropriate narrative texts aligned with the English local content curriculum. Parallel but distinct texts were used for the pretest and posttest to prevent memorization effects. Content validity was established through expert review by the classroom teacher and a language education lecturer, while reliability was estimated via test-retest and inter-rater agreement (Azwar, 2022). Raw scores were processed by scoring multiple-choice items dichotomously and essays using a rubric (0–5 points per item), then converted to a 0–100 scale.

Data were subsequently analyzed through four sequential procedures: (1) descriptive statistics (mean, standard deviation, and range) to characterize score distributions; (2) the Shapiro-Wilk normality test, selected for its superior power with small samples ($n < 50$), to verify parametric assumptions (Razali & Wah, 2011); (3) a Paired Samples t-test to determine whether the mean difference

between pretest and posttest scores was statistically significant; and (4) Normalized Gain (N-Gain) analysis using Hake's (1998) formula — $G = (post-test - pre-test) / (maximum - pre-test)$ — categorized as high ($G \geq 0.70$), moderate ($0.30 \leq G < 0.70$), or low ($G < 0.30$) — to assess individual learning efficiency beyond mean-level gains. All statistical procedures were performed using IBM SPSS Statistics 26.0, and qualitative observation data were analyzed thematically to contextualize the quantitative findings (Grabe & Stoller, 2020).

3. Result

Descriptive Statistics of Pre-test and Post-test Scores

This study involved 21 fifth-grade students of SD Negeri Sidomulyo, assessed via a 10-item multiple-choice and 5-item essay English reading comprehension test (maximum score: 100). The pre-test mean was 68.33 (SD = 14.08), while the post-test mean was 76.43 (SD = 10.51), reflecting a mean increase of 8.10 points. The decrease in post-test standard deviation indicates reduced score variability following the intervention, suggesting more consistent performance outcomes after using the AI Pop-Up Book media (see Table 1; IBM SPSS Statistics 26.0).

Table 1. Descriptive Statistics of Pre-test and Post-test Scores

Statistic	Pre-test	Post-test
N (Students)	21	21
Mean	68.33	76.43
Std. Deviation	14.08	10.51
Minimum Score	30	55
Maximum Score	95	95

Source: IBM SPSS Statistics 26.0 Output

Normality Test (Shapiro-Wilk)

Table 2. Results of the Shapiro-Wilk Normality Test

Data	W (Statistic)	p-value	Sig.	Result
Pre-test	0.885	0.018	< 0.05	Not Normal
Post-test	0.962	0.551	> 0.05	Normal
Difference (Gain)	0.943	0.253	> 0.05	Normal

Source: IBM SPSS Statistics 26.0 Output

The Shapiro-Wilk test was applied given the small sample size ($n = 21 < 50$), as it is more appropriate for small samples than the Kolmogorov-Smirnov test (Razali & Wah, 2011). Results showed the pre-test data were not normally distributed ($W = 0.885$, $p = 0.018$), while both post-test ($W = 0.962$, $p = 0.551$) and difference scores ($W = 0.943$, $p = 0.253$) were normally distributed. Since the paired samples t-test requires normality of difference scores rather than individual distributions, its use remains statistically justified (Field, 2018).

Results of the Paired Samples t-Test

To address the research question regarding the statistical significance of improvement in students' English reading comprehension skills before and after the AI Pop-Up Book intervention, a Paired Samples t-Test was conducted using IBM SPSS Statistics. The statistical hypotheses were formulated as follows:

H_0 : There is no significant difference between the students' pre-test and post-test mean scores.

H_1 : There is a significant difference between the students' pre-test and post-test mean scores.

Table 3. Results of the Paired Samples t-Test

Parameter	Value	df	Sig. (2-tailed)	Decision
Paired Samples t-Test (Pre-Post)	$t = 3.179$	20	0.005	H_0 Rejected
Mean Difference	8.095	–	–	–
Std. Error Mean	2.547	–	–	–

Source: IBM SPSS Statistics 26.0 Output

The paired samples t-test yielded $t = 3.179$, $df = 20$, $p = 0.005 < 0.05$, leading to rejection of H_0 and acceptance of H_1 . There was a statistically significant difference between pre-test ($M = 68.33$) and post-test ($M = 76.43$) scores, with a mean difference of 8.095 points ($SE = 2.547$). This indicates that the AI Pop-Up Book intervention produced a meaningful and statistically significant improvement in students' English reading comprehension scores.

Normalized Gain (N-Gain) Analysis

Table 4. N-Gain Scores per Student

No.	Students	Pre-test	Post-test	N-Gain	Category
1	Student 1	50	60	0.200	Low
2	Student 2	80	95	0.750	High
3	Student 3	65	80	0.429	Moderate
4	Student 4	75	75	0.000	Low
5	Student 5	30	65	0.500	Moderate
6	Student 6	75	90	0.600	Moderate
7	Student 7	75	90	0.600	Moderate
8	Student 8	65	65	0.000	Low
9	Student 9	75	70	-0.200	Low
10	Student 10	95	75	-4.000	Low
11	Student 11	80	80	0.000	Low
12	Student 12	75	90	0.600	Moderate
13	Student 13	70	65	-0.167	Low
14	Student 14	70	80	0.333	Moderate
15	Student 15	60	80	0.500	Moderate
16	Student 16	75	75	0.000	Low
17	Student 17	70	80	0.333	Moderate
18	Student 18	75	85	0.400	Moderate
19	Student 19	55	75	0.444	Moderate
20	Student 20	75	75	0.000	Low

21	Student 21	45	55	0.182	Low
Mean N-Gain				0.072	Low

Table 5. Distribution of N-Gain Categories

Category	Range	Students (n)	Percentage	Description
High	$G \geq 0.70$	1	4.76%	High Gain
Moderate	$0.30 \leq G < 0.70$	10	47.62%	Moderate Gain
Low	$G < 0.30$	10	47.62%	Low/Negative Gain
Total	–	21	100%	–

Source: Processed data, 2025

N-Gain scores were computed using Hake's (1998) formula: $G = (\text{Post} - \text{Pre}) / (\text{Maximum} - \text{Pre})$. The overall mean N-Gain was 0.072 (low category). One student (4.76%) achieved high gain ($G \geq 0.70$), 10 students (47.62%) achieved moderate gain ($0.30 \leq G < 0.70$), and 10 students (47.62%) remained in the low or negative gain category (see Tables 4–5). It is important to note that Student 10, who had a near-ceiling pre-test score of 95 and a post-test decline to 75, produced an extreme negative N-Gain value (–4.000) due to the mathematical properties of Hake's formula when pre-test scores approach the maximum. This value should be interpreted with caution, as it disproportionately lowers the group mean N-Gain.

4. Discussion

Implementation of AI Pop-Up Book Media in the Classroom

The implementation of AI Pop-Up Book media in the English reading comprehension class at SD Negeri Sidomulyo was conducted through structured, multimodal learning sessions that integrated age-appropriate English narrative texts with interactive digital pop-up visuals and AI-adaptive feedback features. Classroom observation data indicated that students demonstrated heightened enthusiasm and sustained engagement throughout the intervention, particularly in response to the three-dimensional visual elements and the immediacy of AI-generated feedback.

This behavioral pattern aligns with multimodal learning principles, which posit that the simultaneous integration of textual, visual, and interactive channels deepens cognitive processing and supports comprehension construction (Mayer, 2009). Furthermore, the adaptive difficulty adjustment enabled by the AI

component is consistent with personalized learning frameworks, in which instructional content is dynamically calibrated to individual performance levels to maximize engagement and minimize unnecessary cognitive load (Maulana & Purwati, 2025; Sunarti et al., 2023). The structured interactivity of the media — requiring students to read, respond to comprehension questions, and receive real-time system feedback — thus created a learning environment qualitatively distinct from conventional text-based instruction.

Discussion of Descriptive Statistics

The quantitative outcomes corroborate this observational evidence. The mean pre-test score of 68.33 (SD = 14.08), falling below the minimum passing threshold of 70, confirmed the reading comprehension deficit characteristic of mixed-ability elementary EFL classrooms (Li et al., 2023; Bogaert et al., 2023). Following the intervention, the post-test mean increased to 76.43 (SD = 10.51), representing a gain of 8.10 points and surpassing the passing threshold. Particularly noteworthy is the concurrent reduction in score dispersion, as the standard deviation decreased from 14.08 to 10.51 — a convergence pattern suggesting not only overall improvement but also greater performance homogeneity across the group.

This equalizing effect is consistent with Chiu et al. (2023), who found that AI-adaptive media tend to disproportionately benefit mid- and lower-performing students by providing structured, scaffolded support, while continuing to sustain engagement among higher achievers. The pattern thus suggests that AI Pop-Up Book media may serve a leveling function within heterogeneous classrooms, an implication with meaningful pedagogical relevance for the Indonesian elementary EFL context.

Discussion of Paired Samples t-Test Results

Inferential analysis further strengthened these findings. Prior to conducting the Paired Samples t-Test, the Shapiro-Wilk test — selected for its superior statistical power with small samples ($n = 21 < 50$) relative to the Kolmogorov-Smirnov test (Razali & Wah, 2011) — revealed a non-normal pre-test distribution ($W = 0.885$, $p = 0.018$), reflecting the heterogeneous baseline proficiency typical of mixed-ability classrooms. Crucially, however, both the post-test ($W = 0.962$, $p = 0.551$) and the difference scores ($W = 0.943$, $p = 0.253$) satisfied the normality assumption. Since the Paired Samples t-Test requires normality of the difference scores rather than of the individual distributions (Field, 2018), the parametric test remained statistically appropriate. The test yielded $t(20) = 3.179$, $p = 0.005 < 0.05$, with a mean difference of 8.095 points (SE = 2.547), leading to the rejection of the null hypothesis and confirming a statistically significant improvement in reading comprehension scores following the intervention.

This result converges with Hidayat (2024), who reported significant comprehension gains through AI-personalized reading platforms, and with Shafiee Rad (2025), who demonstrated that AI interventions meaningfully reinforce self-regulated reading strategies. It also aligns with Sunarti et al. (2023), whose pop-up book intervention produced significant posttest improvements in elementary reading skill outcomes. The statistical significance obtained here therefore represents convergent evidence across two independently validated instructional paradigms — AI-adaptive instruction and pop-up visual engagement — supporting the theoretical premise that their integration amplifies the instructional effect achievable by either approach in isolation.

Discussion of N-Gain Analysis

While the paired t-test confirms the significance of mean-level gains, Normalized Gain (N-Gain) analysis provides a more granular account of individual learning efficiency. The group mean N-Gain of 0.072 falls in the low category, but this aggregate figure is substantially distorted by a single extreme outlier: Student 10 entered the study with a near-ceiling pre-test score of 95, producing an N-Gain of -4.000 when the post-test score declined to 75.

This extreme negative value is a well-documented mathematical artifact of Hake's (1998) formula under ceiling conditions, in which the denominator (maximum score – pre-test score) approaches zero, rendering the index analytically meaningless rather than indicative of genuine learning regression. Excluding this outlier, the distribution across the remaining 20 students presents a more representative picture: 10 students (47.62%) achieved moderate gains ($0.30 \leq G < 0.70$) and 1 student (4.76%) achieved high gain ($G \geq 0.70$), meaning that 11 students (55% of the valid sample) demonstrated meaningful learning progress.

This pattern is consistent with Huda and Kiptiyah (2024), who found that digital pop-up book interventions produced significant outcome improvements in specific student subgroups, and with Yaseen et al. (2025), who established that the effectiveness of personalized AI feedback is moderated by students' digital literacy levels. The 10 students who remained in the low or negative gain category may reflect the cognitive overload arising from simultaneous multimodal input documented by Noori (2025), limited prior familiarity with AI-based tools (Lin et al., 2025), or individual variation in reading motivation and self-regulation capacity that brief, single-exposure interventions cannot fully address (Li et al., 2023).

Pedagogical Implications

These findings carry several important pedagogical implications. Most critically, the effectiveness of AI Pop-Up Book media is not unconditional: it appears contingent upon adequate teacher scaffolding, students' prior digital literacy, and

the duration of the intervention. Students who lack metacognitive strategies or are unfamiliar with adaptive technology are likely to experience cognitive distraction rather than comprehension gain, underscoring the necessity of pre-intervention digital literacy orientation and explicit reading strategy instruction (Li et al., 2023; Kristiawan et al., 2024).

School administrators likewise bear responsibility for ensuring stable technological infrastructure and supporting extended implementation periods sufficient for measurable learning gains to consolidate. Researchers should additionally remain attentive to ceiling effects in N-Gain analysis, as near-maximum pre-test scores can produce extreme negative values that distort group-level interpretation and misrepresent the medium's actual instructional value.

Limitations

The present study is subject to several limitations that constrain the generalizability and causal interpretability of its findings. First, the absence of a control group in the pre-experimental one-group pretest-posttest design precludes the attribution of observed gains exclusively to the AI Pop-Up Book intervention, as alternative explanations — including history effects, maturation, and testing effects — cannot be ruled out (Creswell & Creswell, 2023). Second, the small sample size ($n = 21$) reduces statistical power and limits generalizability beyond the study context (Cohen, 1988). Third, the non-normal pre-test distribution ($W = 0.885$, $p = 0.018$) signals substantial baseline heterogeneity that may have influenced post-test outcomes independently of the intervention. Fourth, the extreme N-Gain outlier (-4.000) resulting from a ceiling pre-test score substantially depressed the group mean, complicating straightforward interpretation of aggregate learning efficiency. Fifth, several contextual variables relevant to technology-based learning — including device conditions, internet access stability, and individual technology familiarity — were not systematically controlled, potentially introducing unaccounted sources of variance.

Future research is therefore recommended to adopt a true experimental design with random assignment and a control group, employ larger samples ($n \geq 30$ per group), extend the intervention duration to allow cumulative effects to emerge, and systematically measure moderating variables such as digital literacy and reading motivation to produce stronger, more generalizable evidence for the effectiveness of AI Pop-Up Book media in elementary EFL reading comprehension instruction.

5. Conclusion

This study examined the use of AI Pop-Up Book media in English reading comprehension instruction for fifth-grade students at SD Negeri Sidomulyo. Based on IBM SPSS analysis of pre-test and post-test data from 21 students, three key conclusions are drawn.

First, the AI Pop-Up Book was implemented through structured, multimodal learning sessions that integrated interactive visuals and AI-adaptive feedback, generating observable student engagement throughout the intervention.

Second, the Paired Samples t-Test ($t = 3.179$, $p = 0.005 < 0.05$) indicated a statistically significant difference between pre-test ($M = 68.33$) and post-test ($M = 76.43$) scores, with a mean improvement of 8.095 points, confirming that the AI Pop-Up Book media significantly enhanced students' reading comprehension.]

Third, the mean N-Gain of 0.072 (low category overall) reflected modest group-level gain; however, 11 students (52.38%) achieved moderate to high gains, demonstrating meaningful learning progress for a substantial portion of the class. The low mean N-Gain is partly attributable to an extreme outlier value from one student with a near-ceiling pre-test score. Overall, these findings indicate that AI Pop-Up Book media has genuine potential to improve elementary EFL reading comprehension, and its effectiveness can be further optimized with adequate scaffolding, extended intervention time, and stronger student digital readiness.

Suggestion

Based on the findings of this study, several suggestions are offered to relevant stakeholders. Teachers are encouraged to provide digital literacy orientation prior to implementation and to integrate explicit reading comprehension strategy instruction alongside the media to optimize learning outcomes. School administrators should ensure stable technological infrastructure and support extended implementation periods to allow measurable effects to emerge. Future researchers are recommended to adopt a true experimental design with a control group, a larger sample size ($n \geq 30$ per group), and a longer intervention duration to generate stronger and more generalizable evidence.

Researchers should also be attentive to pre-test ceiling effects when using N-Gain as an outcome measure, as near-maximum pre-test scores can produce misleading extreme negative values. Exploration of additional moderating variables such as digital literacy and reading motivation is also encouraged. Finally, instructional media developers should prioritize intuitive interfaces and built-in metacognitive prompts so that young EFL learners can engage meaningfully with reading content without being cognitively overloaded by the technology itself.

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