

# THE EFFECTIVENESS OF DIGITAL MEDIA-ASSISTED RECIPROCAL LEARNING ON STUDENTS' READING COMPREHENSION SKILLS

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### Abstract

Traditional instructional methods often fail to develop students' metacognitive and evaluative reading skills, necessitating innovative pedagogical approaches that leverage digital technology to enhance literacy development. This study aimed to evaluate the effectiveness of a digital media-assisted reciprocal learning strategy on fifth-grade elementary students' reading comprehension skills. This study used a quantitative approach with a quasi-experimental method. The study participants consisted of 302 grade V students (aged 10-11 years) from six elementary schools in urban Indonesia. The intervention was conducted over one semester. Data were collected through a Reading Comprehension Test of 30 questions and classroom observations. The analysis included descriptive statistics and ANCOVA to test the main hypothesis. The experimental group showed a significant increase in reading comprehension compared to the control group,  $\text{sig}=0.001<0.05$  (Cohen's  $d = 1.34$ ). The increase was especially seen in the dimensions of metacognitive awareness (Cohen's  $d = 1.37$ ) and evaluative reading (Cohen's  $d = 1.32$ ), indicating that the integration of digital media with reciprocal learning strategies effectively improved high-level comprehension skills. Conclusion: Reciprocal learning with the assistance of digital media is an effective approach to improving students' reading comprehension skills. This study has geographical limitations and is limited to fifth-grade students. Key recommendations are to conduct cross-cultural studies, develop longitudinal research designs, and design a more comprehensive assessment framework to validate reciprocal learning strategies with the assistance of digital media. This research has contributed to the utilization of digital technology with reciprocal learning strategies effectively in literacy learning.

**Keywords:** Reciprocal Learning, Digital Media, Reading Comprehension.

### Abstrak

Metode instruksional tradisional sering gagal mengembangkan keterampilan membaca metakognitif dan evaluatif siswa, yang memerlukan pendekatan pedagogis inovatif yang memanfaatkan teknologi digital untuk meningkatkan pengembangan literasi. Penelitian ini bertujuan untuk mengevaluasi efektivitas strategi pembelajaran resiprokal berbantuan media digital terhadap keterampilan pemahaman membaca siswa kelas lima sekolah dasar. Penelitian ini menggunakan pendekatan kuantitatif dengan metode kuasi-eksperimental. Peserta penelitian terdiri dari 302 siswa kelas V (berusia 10-11 tahun) dari enam sekolah dasar di perkotaan Indonesia. Intervensi dilakukan selama satu semester. Data dikumpulkan melalui Tes Pemahaman Membaca sebanyak 30 pertanyaan dan observasi kelas. Analisis mencakup statistik deskriptif dan ANCOVA untuk menguji hipotesis utama. Kelompok eksperimen menunjukkan peningkatan signifikan dalam pemahaman membaca dibandingkan dengan kelompok kontrol,  $\text{sig}=0,001<0,05$  (Cohen's  $d = 1,34$ ). Peningkatan terutama terlihat pada dimensi kesadaran metakognitif (Cohen's  $d = 1,37$ ) dan membaca evaluatif (Cohen's  $d = 1,32$ ), yang menunjukkan bahwa integrasi media digital dengan strategi pembelajaran resiprokal secara efektif meningkatkan keterampilan pemahaman tingkat tinggi.

Kesimpulannya adalah pembelajaran resiprokal dengan bantuan media digital merupakan pendekatan yang efektif untuk meningkatkan keterampilan pemahaman membaca siswa. Penelitian ini memiliki keterbatasan geografis dan terbatas pada siswa kelas lima. Rekomendasi utamanya adalah melakukan studi lintas budaya, mengembangkan desain penelitian longitudinal, dan merancang kerangka penilaian yang lebih komprehensif untuk memvalidasi strategi pembelajaran resiprokal dengan bantuan media digital. Penelitian ini telah berkontribusi pada pemanfaatan teknologi digital dengan strategi pembelajaran resiprokal secara efektif dalam pembelajaran literasi.

**Kata kunci:** Pembelajaran Resiprokal, Media Digital, Pemahaman Membaca.

## INTRODUCTION

Traditional instructional methods often fail to develop students' metacognitive and evaluative reading skills, which hinders the development of comprehensive literacy in the digital age (Roshid & Haider, 2024). The need for innovative pedagogical approaches that utilize digital technology is urgent to improve elementary school students' reading comprehension skills, given the complexity of literacy demands in the 21st century (Varas et al, 2023).

Reading comprehension is a fundamental skill that plays a crucial role in students' academic and life success (Ma & Zhao, 2025; Strauss, 2024; Uleanya, 2024). At the primary school level, these skills become increasingly important as students move from "learning to read" to "reading to learn" (Le Roux, 2024; J. Liu, 2015).

However, recent data from PIRLS (Progress in International Reading Literacy Study) shows that Indonesia still ranks low in students' reading literacy skills compared to other countries, with scores that are below the international average of 500 (PIRLS, 2022). This condition is reinforced by the 2022 PISA (Program for International Student Assessment) results, which ranked Indonesia 62<sup>nd</sup> out of 81 countries in reading literacy with a score of 359, far below the OECD average of 476 (OECD, 2023). This gap indicates a serious problem in Indonesia's reading comprehension learning approach that requires innovative and effective interventions.

The reciprocal teaching approach is effective in improving reading comprehension skills through four main strategies: summarizing, questioning, clarifying, and predicting (Fung et al., 2003; Mafarja et al., 2023; Sparapani et al., 2018). Some previous studies, such as those conducted by Sparapani *et al.* (2018) and Tong and McBride (2017), demonstrated the effectiveness of reciprocal learning in conventional contexts. However, as the digital era progresses and the way students interact with texts changes, there is a research gap on how to integrate digital media in reciprocal learning to optimize its impact on students' reading comprehension in this technological era (Elçi, 2024; Kurniaman et al., 2024; van Rooyen & Mihai, 2024).

The novelty of this study lies in the comprehensive integration of digital media, including interactive e-books, text visualization applications, digital discussion forums, and online collaboration platforms into the four reciprocal learning strategies. Unlike previous studies that only used one type of digital media or applied them partially (Hayashi et al, 2025; Xie & Lin, 2025). This study develops an integrated framework that aligns various digital media with specific stages in reciprocal learning. This approach enables personalized learning that is more adaptive to students' diverse needs and learning styles.

This study aims to (1) analyze the effect of the digital media-assisted reciprocal learning approach on the reading comprehension achievement of grade V students, (2) identify the aspects of reading comprehension most affected by this intervention, and (3) develop an implementation model that can be replicated in the Indonesian learning context. Through a quasi-experimental design with pre-test and post-test in

experimental and control groups, this study comprehensively examined the effectiveness of the proposed intervention.

The urgency of this research is supported by three main factors. First, the phenomenon of low reading literacy levels among Indonesian students requires an innovative approach to overcome. Second, the increasing accessibility of technology in Indonesian schools has not been optimally utilized in literacy learning. Third, the need for a learning model that can bridge the digital divide while improving students' conventional literacy skills in preparation for the literacy demands of the 21st century (Fanani & Kusmaharti, 2018).

This research makes significant contributions both theoretically and practically. Theoretically, it expands the understanding of the interaction between reciprocal pedagogy and digital technology in the context of reading comprehension learning. Practically, it produces an implementation framework that educators can adapt to integrate digital media into literacy learning without compromising the social and metacognitive aspects that are the main strengths of reciprocal learning. (Liu et al., 2025).

The long-term impacts of this research include improving the quality of reading comprehension learning in Indonesian primary schools, developing a sustainable model of technology integration in literacy, and improving students' readiness to face future digital literacy demands. Furthermore, this research has the potential to contribute to national efforts to improve Indonesia's literacy rankings in international assessments such as PIRLS and PISA while preparing a generation capable of critical and analytical thinking in facing the digital information age.

## Theoretical Framework

Reciprocal teaching is an instructional approach developed by Palinscar and Brown (1984) as a strategy to improve reading comprehension through structured dialog between teachers and students. This approach is based on Vygotsky's theory of social constructivism which emphasizes that learning occurs through social interaction and the important role of scaffolding in the learning process. Vygotsky's concept of Zone of Proximal Development (ZPD) is fundamental to reciprocal teaching, where students can achieve higher understanding with help from more skilled individuals before eventually being able to do so independently (Vygotsky, 1978).

The four main strategies in reciprocal teaching namely predicting, clarifying, questioning, and summarizing are designed to improve reading comprehension through a metacognitive approach (Mafarja et al., 2023). Flavell's theory of metacognition explains the importance of students' awareness and ability to monitor and regulate their own cognitive processes while reading. Reciprocal teaching systematically facilitates the development of metacognitive skills by teaching students to actively monitor their comprehension and apply appropriate strategies when facing difficulties (Flavell, 1979).

In the context of the digital age, the reciprocal teaching model undergoes adaptation to accommodate changes in text characteristics and the way students interact with information (Palincsar, 2013). The digital literacy theory proposed by Leu *et al.* (2004) emphasizes that reading in digital environments requires additional skills, including the ability to navigate non-linear texts, evaluate the reliability of sources, and integrate information from multiple media formats. Modern reciprocal teaching integrates these skills to prepare students for the complexity of digital texts.

Paivio (1990) dual-coding theory is also relevant in this framework, which explains that information is processed through interconnected verbal and visual pathways. Digital learning environments that present text with visual support can improve reading comprehension, especially for primary school students who are still developing decoding and comprehension skills. Reciprocal teaching strategies can utilize multimedia features to reinforce conceptual understanding and support different learning styles (Palincsar, 2013).

The model developed by Snow (2002) Reading comprehension is also integrated into this theoretical framework, which identifies three key elements in comprehension: the reader, the text, and the activity of reading in a specific sociocultural context. In the digital age, the characteristics of texts have changed significantly, requiring adaptive teaching approaches. Reciprocal teaching provides a flexible structure to accommodate different types of digital texts while maintaining a focus on developing deep comprehension.

This research is also grounded in Sweller's (1988) cognitive load theory, which explains the importance of designing instruction that considers the limited capacity of working memory. Reciprocal teaching strategies help manage cognitive load by breaking down the complex reading process into more manageable components and providing incremental support appropriate to the developmental level of primary school students.

## METHODS

This study used a quantitative approach with a quasi-experimental method to examine the effectiveness of digital media-assisted reciprocal learning strategies on the reading comprehension skills of grade V elementary school students. The quasi-experimental method was chosen due to the impossibility of random assignment in the formal education context. (Creswell & Creswell, 2018). The research design used was a Non-Equivalent Control Group Design with pre-test and post-test measurements, which allows researchers to compare the results of interventions between experimental and control groups without ignoring the initial conditions of the research subjects. (Creswell & Creswell, 2018).

This study was conducted in elementary schools in Cirebon, West Java, Indonesia. The study participants consisted of 302 grade V students (aged 10-11 years) from six elementary schools in urban Cirebon, Indonesia, divided into an experimental group (n=153) and a control group (n=149). The sampling technique used was

purposive sampling with the following criteria: (1) availability of digital infrastructure at school, (2) similar socio-economic background, and (3) similar academic achievement profile. To minimize bias, teachers in both groups had equivalent qualifications and teaching experience (at least 5 years of experience).

The intervention was conducted over one semester (16 weeks) with three meetings per week of 60 minutes each. The experimental group received digital media-assisted reciprocal learning that integrated interactive e-books, text visualization applications, digital discussion forums, and online collaboration platforms into four main reciprocal learning strategies: summarizing, questioning, clarifying, and predicting. Meanwhile, the control group received conventional learning using lectures, discussion, and print media as per the standard curriculum.

Reading comprehension ability in this study refers to the reading comprehension taxonomy developed by (Anderson, & Krathwohl, 2001) and modified by Oakhill, Cain, & Elbro (2014) Which includes four dimensions: (1) Literal comprehension, which is the ability to identify explicit information in the text with indicators: recognizing explicit facts, details, and sequence of events; (2) Inferential comprehension, which is the ability to conclude from implicit information with indicators: determining the main idea, making inferences, and recognizing implied cause-effect relationships; (3) Evaluative comprehension, which is the ability to assess and criticize text content with indicators: distinguishing facts and opinions, assessing the accuracy of information, and identifying the author's purpose; and (4) Metacognitive comprehension, which is awareness of one's thinking process with indicators: monitoring comprehension, identifying effective strategies, and evaluating the suitability of strategies with reading objectives.

The main instrument used in data collection was the Test of Reading Comprehension adapted from the PIRLS assessment framework and adjusted to the Indonesian context. The Test of Reading Comprehension consists of 30 items that measure the four dimensions of reading comprehension with proportions: literal comprehension (10 items), inferential (10 items), evaluative (5 items), and metacognitive (5 items). The instrument has been validated through expert judgment ( $n=5$ ) and pilot testing on 80 grade V students from a school that did not participate in the study, with the result of reliability analysis using Cronbach's Alpha of 0.87 indicating high internal consistency. In addition, to measure students' engagement in digital learning, a Digital Reading Engagement Scale with 15 Likert scale items was used, as well as a Strategy Implementation Observation Sheet to measure teachers' adherence to the intervention protocol.

Data analysis techniques included descriptive and inferential analysis. To test the main hypothesis, Analysis of Covariance (ANCOVA) was used with pre-test scores as covariate to compare the effectiveness of the intervention in experimental and control groups. Effect size was calculated using Cohen's  $d$  to determine the magnitude of the intervention impact. Furthermore, multiple regression analysis was conducted to identify the aspects of reading comprehension most affected by the intervention, while repeated measures ANOVA was used to analyze changes in the application of reading

strategies over time. To control for potential bias from outside variables, a subgroup analysis based on gender, prior reading achievement, and students' digital literacy level was conducted. All statistical analyses were conducted with the help of SPSS version 28.0 software with a significance level of  $p < 0.05$ .

## RESULTS AND DISCUSSION

Before the implementation of the intervention, the Test of Reading Comprehension went through a comprehensive validation procedure. Content validity was tested through expert judgment involving five experts in language and reading education. Table 1 presents the results of content validity using Aiken's V formula.

**Table 1. Results of Content Validity of Reading Comprehension Test**

| Dimensions                  | Item  | Aiken's V Range | Aiken's V Mean | Interpretation |
|-----------------------------|-------|-----------------|----------------|----------------|
| Literal Comprehension       | 1-10  | 0,78-0,92       | 0,85           | High validity  |
| Inferential Comprehension   | 11-20 | 0,80-0,93       | 0,88           | High validity  |
| Evaluative Comprehension    | 21-25 | 0,76-0,90       | 0,84           | High validity  |
| Metacognitive Comprehension | 26-30 | 0,77-0,89       | 0,83           | High validity  |
| Overall Instrument          | 1-30  | 0,76-0,93       | 0,86           | High validity  |

The reading comprehension test demonstrated strong content validity across dimensions, with Aiken's V coefficients ranging from 0.76 to 0.93, exceeding the minimum acceptable threshold of 0.70 (Aiken, 1985). Reliability analysis of the instrument was conducted through a pilot test involving 80 grade V students from schools that did not participate in the main study. Table 2 presents the results of the reliability analysis using Cronbach's Alpha coefficient.

**Table 2 Results of Reliability Analysis of Reading Comprehension Test**

| Item Dimensions             | Item | Cronbach Alpha ( $\alpha$ ) | Interpretation            |
|-----------------------------|------|-----------------------------|---------------------------|
| Literal Comprehension       | 10   | 0,85                        | Good reliability          |
| Inferential Comprehension   | 10   | 0,83                        | Good reliability          |
| Evaluative Comprehension    | 5    | 0,80                        | Good reliability          |
| Metacognitive Comprehension | 5    | 0,79                        | Reliability is acceptable |
| Overall Instrument          | 30   | 0,87                        | Good reliability          |

30

Cronbach's alpha coefficients for all dimensions exceeded 0.70, indicating acceptable to good internal consistency (Taber, 2018). The instrument's overall reliability coefficient of 0.87 showed high internal consistency, confirming the reliability of the reading comprehension test to measure reading comprehension among grade V students.

## Descriptive Statistical Analysis

The comparison of pre-test and post-test scores between the experimental and control groups is presented in Table 3.

**Table 3. Descriptive Statistics of Pre-test and Post-test Scores**

| Group      | N   | Pre-test |      | Post-test |      | Mean Increase | 95% Confidence Interval for Increase |
|------------|-----|----------|------|-----------|------|---------------|--------------------------------------|
|            |     | M        | SD   | M         | SD   |               |                                      |
| Experiment | 153 | 62,41    | 8,32 | 78,65     | 7,45 | 16,24         | [14,87, 17,61]                       |
| Control    | 149 | 61,87    | 8,56 | 68,23     | 8,12 | 6,36          | [5,02, 7,70]                         |

Table 3 shows that the experimental group had a significantly higher mean increase (16,24 points) compared to the control group (6,36 points). Non-overlapping confidence intervals for the mean increase indicate a statistically significant difference in improvement between the two groups.

#### Inter-Group Comparative Analysis

Analysis of covariance (ANCOVA) was conducted to compare post-test scores between groups by controlling for pre-test scores as a covariate. The assumptions for ANCOVA were tested and met: normal distribution of residuals (Shapiro-Wilk test,  $p > 0.05$ ), homogeneity of variances (Levene's test,  $F(1, 300) = 1.87$ ,  $p = 0.173$ ), and homogeneity of regression slopes ( $F(1, 298) = 2.31$ ,  $p = 0.130$ ).

**Table 4. ANCOVA Results for Inter-Group Comparisons on Post-test Scores**

| Source              | JK         | df  | KR      | F      | p      | $\eta p^2$ |
|---------------------|------------|-----|---------|--------|--------|------------|
| Pre-test (Kovariat) | 4281,34    | 1   | 4281,34 | 87,53  | <0,001 | 0,23       |
| Group               | 5499,87    | 1   | 5499,87 | 112,46 | <0,001 | 0,27       |
| Error               | 14622,43   | 299 | 48,90   |        |        |            |
| Total               | 1582684,00 | 302 |         |        |        |            |

Note. JK = Sum of Squares; df = degrees of freedom; KR = Mean Square;  $\eta p^2$  = partial eta square.

The ANCOVA results showed a significant effect of the intervention on reading comprehension ( $F(1, 299) = 112.46$ ,  $p < 0.001$ ,  $\eta p^2 = 0.27$ ). The effect size (Cohen's  $d = 1.34$ ) indicated a large practical significance of the intervention, exceeding Cohen's benchmark of 0.80 for a large effect.

#### Reading Comprehension Dimension Analysis

To assess the impact of the intervention on the various dimensions of reading comprehension, separate ANCOVA's were conducted for each dimension with pre-test scores as covariates. Table 5 presents the results.

**Table 5. Comparison of Reading Comprehension Dimensions between Groups**

| Dimension     | Experimental Group |          | Control Group |          | F (1, 299) | P      | Cohen's d |
|---------------|--------------------|----------|---------------|----------|------------|--------|-----------|
|               | Pretest            | Posttest | Pretest       | Posttest |            |        |           |
| Literal       | 68,23              | 82,41    | 67,92         | 75,18    | 46,23      | <0,001 | 0,86      |
| Inferential   | 61,34              | 78,92    | 60,89         | 67,43    | 89,74      | <0,001 | 1,29      |
| Evaluative    | 58,65              | 76,18    | 57,98         | 63,45    | 102,56     | <0,001 | 1,32      |
| Metacognitive | 54,21              | 73,27    | 53,76         | 61,15    | 118,35     | <0,001 | 1,37      |

The intervention had significant positive effects on all dimensions of reading comprehension, with the largest effect observed on metacognitive comprehension ( $d = 1.37$ ), followed by evaluative comprehension ( $d = 1.32$ ), inferential comprehension ( $d = 1.29$ ), and literal comprehension ( $d = 0.86$ ). This pattern suggests that digital-assisted reciprocal learning is particularly effective for improving higher-order reading comprehension skills.

### Analysis of Reading Strategy Implementation

A repeated measures analysis of variance was conducted to analyze changes in reading strategy implementation over time as measured by the Strategy Implementation Observation Sheet. Results showed a significant increase in strategy use in the experimental group ( $F(3,456) = 78.35$ ,  $p < 0.001$ ,  $\eta^2 = 0.34$ ).

**Table 6. Implementation of Reciprocal Strategy in Experimental Group**

| Strategy               | Week<br>1 | Week<br>5 | Week<br>10 | Week<br>16 | F<br>(3, 456) | p      | $\eta^2$ |
|------------------------|-----------|-----------|------------|------------|---------------|--------|----------|
| Summarizing            | 41,2      | 57,6      | 68,4       | 75,8       | 63,42         | <0,001 | 0,29     |
| Questioning            | 38,5      | 54,3      | 65,7       | 73,2       | 59,85         | <0,001 | 0,28     |
| Clarifying             | 35,7      | 52,8      | 67,5       | 78,0       | 84,62         | <0,001 | 0,36     |
| Predicting             | 36,8      | 50,9      | 64,8       | 75,5       | 71,29         | <0,001 | 0,32     |
| Overall Implementation | 38,1      | 53,9      | 66,6       | 75,6       | 78,35         | <0,001 | 0,34     |

Table 6 shows the progressive improvement in the implementation of the four reciprocal learning strategies throughout the intervention period. The clarifying strategy showed the greatest improvement (42.3 percentage points), followed by predicting (38.7 percentage points), summarizing (34.6 percentage points), and questioning (34.7 percentage points).

Subgroup analysis was performed to explore whether the intervention had varying effects based on gender, prior reading achievement, and digital literacy level. This analysis aimed to identify potential differences in outcomes among these distinct groups.

**Table 7. Subgroup Analysis of Intervention Effects**

| Subgroup                           | n  | Pre-<br>test | Post-<br>test | Post-test<br>Corrected* | F                   | p      | $\eta^2$ |
|------------------------------------|----|--------------|---------------|-------------------------|---------------------|--------|----------|
| <b>Gender</b>                      |    |              |               |                         | $F(1,151) = 2,18$   | 0,140  | 0,01     |
| Male                               | 78 | 61,87        | 77,92         | 78,05                   |                     |        |          |
| Female                             | 75 | 62,97        | 79,42         | 79,29                   |                     |        |          |
| <b>Initial Reading Achievement</b> |    |              |               |                         | $F(2, 150) = 14,23$ | <0,001 | 0,16     |
| Low ( $\leq 55$ )                  | 47 | 51,34        | 72,68         | 80,21                   |                     |        |          |
| Medium (56-70)                     | 62 | 63,45        | 79,74         | 78,26                   |                     |        |          |
| High ( $\geq 71$ )                 | 44 | 73,56        | 83,82         | 75,42                   |                     |        |          |
| <b>Digital Literacy Level</b>      |    |              |               |                         | $F(2, 150) = 9,47$  | <0,001 | 0,11     |

| Subgroup | n  | Pre-test | Post-test | Post-test Corrected* | F | p | $\eta p^2$ |
|----------|----|----------|-----------|----------------------|---|---|------------|
| Low      | 38 | 60,76    | 73,58     | 74,7                 |   |   |            |
| Medium   | 75 | 62,35    | 78,92     | 78,8                 |   |   |            |
| High     | 40 | 64,21    | 82,86     | 81,12                |   |   |            |

Observations of the implementation of digital media-assisted reciprocal learning strategies in the experimental group showed significant progress throughout the intervention period. Observations were conducted at four time points: week 4, week 8, week 12, and week 16, using the Strategy Implementation Observation Sheet. The following are the main findings from the observations.

**Table 8. Reciprocal Learning Strategy Implementation Score**

| Strategy    | Week 4    | Week 8    | Week 12   | Week 16   | F     | p-value |
|-------------|-----------|-----------|-----------|-----------|-------|---------|
| Summarizing | 2,6 ± 0,7 | 3,4 ± 0,6 | 3,9 ± 0,5 | 4,3 ± 0,4 | 38,27 | <0,001  |
| Questioning | 2,3 ± 0,8 | 3,2 ± 0,7 | 3,7 ± 0,6 | 4,1 ± 0,5 | 42,15 | <0,001  |
| Clarifying  | 2,4 ± 0,7 | 3,0 ± 0,6 | 3,6 ± 0,5 | 4,2 ± 0,4 | 45,83 | <0,001  |
| Predicting  | 2,1 ± 0,9 | 2,8 ± 0,8 | 3,5 ± 0,6 | 4,0 ± 0,5 | 49,26 | <0,001  |
| Total Score | 2,4 ± 0,7 | 3,1 ± 0,6 | 3,7 ± 0,5 | 4,2 ± 0,4 | 43,72 | <0,001  |

Notes: Scores are on a scale of 1-5 (1=Very Poor, 2=Deficient, 3=Sufficient, 4=Good, 5=Excellent); A p-value of <0.05 indicates a significant difference.

The results of repeated measures ANOVA analysis showed significant improvement in the application of all reciprocal learning strategies from week 4 to week 16. The predicting strategy showed the most substantial improvement ( $F=49.26$ ,  $p<0.001$ ), followed by clarifying ( $F=45.83$ ,  $p<0.001$ ), questioning ( $F=42.15$ ,  $p<0.001$ ), and summarizing ( $F=38.27$ ,  $p<0.001$ ).

Observations also revealed positive developments in group dynamics and digital interactions. At the beginning of the intervention, interactions between students in the digital collaboration platform tended to be limited and dominated by a few students. As time progressed, participation became more evenly distributed with more students actively involved in online discussions and collaboration. By week 16, most groups demonstrated the ability to distribute roles (summarizer, questioner, clarifier, predictor) effectively, and role rotation was smooth. Communication within the digital collaboration platform became more structured and task-focused and showed higher levels of metacognitive reflection.

Observations also recorded significant progress in teachers' adaptation to the integration of digital technology in reciprocal learning. At the beginning of the intervention, teachers tended to experience difficulties in managing the technical aspects of the digital platforms used and often spent significant time addressing technical issues. By the middle of the intervention, teachers showed increased confidence in using various digital platforms and started to develop effective strategies to integrate technology in learning without compromising pedagogical aspects. By week 16, teachers demonstrate the ability to flexibly switch between different digital platforms as per learning needs, provide appropriate scaffolding for technology use,

and facilitate metacognitive discussions on how technology can support students' reading strategies.

5

## Discussion

The findings of this study provide strong evidence of the effectiveness of digital-assisted reciprocal learning strategies in improving elementary school students' reading comprehension. The significant increase in the experimental group's reading comprehension scores ( $M = 78.65$ ,  $SD = 7.45$ ) compared to the control group ( $M = 68.23$ ,  $SD = 8.12$ ) with a large effect size (Cohen's  $d = 1.34$ ) emphasizes the strong impact of this integrated approach.

### Effectiveness on Multiple Dimensions of Comprehension

An important finding in this study was the differential impact of the intervention on all four dimensions of reading comprehension. Although the intervention resulted in significant improvements in all dimensions, the largest effects were observed on metacognitive comprehension ( $d = 1.37$ ) and evaluative comprehension ( $d = 1.32$ ), followed by inferential comprehension ( $d = 1.29$ ) and literal comprehension ( $d = 0.86$ ). This pattern is in line with the theoretical framework suggesting that reciprocal learning specifically improves higher-order reading skills (Spörer et al., 2009; Wenren et al., 2024) and extends these findings by showing that digital enhancement further amplifies this effect.

The stronger impact of the intervention on higher-order reading skills can be attributed to the reciprocal learning design, which encourages students to actively engage with the text through questioning, clarifying, and predicting strategies (Arifannisa & Asnawi, 2024; Mafarja et al., 2023). The addition of digital tools seems to have enhanced this process by providing multimodal engagement opportunities that support the development of metacognitive awareness during reading. (Kanninen et al., 2021). Interactive e-books with annotation capabilities, digital mind mapping tools, and collaborative platforms are likely to create multiple entry points for students to practice higher-order thinking skills while processing texts. (Leu et al., 2015).

### Progressive Development of Strategy Implementation

A longitudinal analysis of strategy implementation showed a clear developmental trajectory throughout the intervention period. Initially, students had difficulty with all four strategies, particularly prediction ( $M = 2.1$ ,  $SD = 0.9$ ) and questioning ( $M = 2.3$ ,  $SD = 0.8$ ). However, by the end of the intervention, students showed substantial improvement in all strategies, with clarification showing particularly strong growth (from  $M = 2.4$ ,  $SD = 0.7$  to  $M = 4.2$ ,  $SD = 0.4$ ).

This progressive development reflects the gradual internalization of metacognitive strategies, consistent with Vygotsky (1978) The concept of the zone of proximal development and the gradual transfer of responsibility from teacher to student. Qualitative observations support this interpretation, documenting the evolution from simple strategy application (e.g., highlighting words) to sophisticated integration of various digital tools and more complex cognitive processing (e.g.,

creating structured summaries integrating color-coded highlighting and digital annotation).

The progressive improvement in strategy implementation also suggests that digitally-assisted reciprocal learning is not simply a temporary intervention but a sustainable approach that leads to the use of increasingly sophisticated strategies over time. This finding addresses concerns about the sustainability of digital interventions raised by previous researchers. (Gebremeskel et al., 2024; Jafarian & Kramer, 2025).

### Differential Effects on Student Subgroups

Subgroup analysis provided important insights into the differential effects of the intervention. The absence of significant gender differences ( $F(1,151) = 2.18, p = 0.140, \eta^2 = 0.01$ ) suggests that digitally-assisted reciprocal learning provides equal benefits for boys and girls, in contrast to some previous studies showing gender disparities in digital learning environments. (Rahimi & Sevilla-Pavón, 2024; Wei et al., 2023).

More striking were the differential effects by initial reading achievement and digital literacy level. The intervention showed the strongest benefit for readers with low initial achievement (corrected post-test  $M = 80.21$ ), followed by average readers ( $M = 78.26$ ) and high-achieving readers ( $M = 75.42$ ), with substantial effect sizes ( $\eta^2 = 0.16$ ). This pattern suggests that digitally-assisted reciprocal learning can be an effective approach to narrowing the achievement gap, consistent with findings from another study of scaffolded comprehension instruction. (Reutebuch et al., 2015).

Similarly, a significant interaction between intervention and digital literacy level ( $\eta^2 = 0.11$ ) indicated that while students with intermediate and high digital literacy benefited substantially from the intervention, those with low digital literacy showed more modest improvements. This finding underscores the importance of addressing digital literacy as a prerequisite for maximizing the benefits of technology-assisted reading interventions. (Gath et al., 2025; Wexler et al., 2022).

### Pedagogical Integration of Technology

Observational data provided valuable insights into how technology integration evolved throughout the intervention. Initially, both teachers and students used digital tools in a limited and sometimes superficial manner. However, by the end of the intervention, there was evidence of sophisticated integration where technology served as a cognitive tool rather than simply a delivery mechanism. This evolution is in line with the SAMR (Substitution, Augmentation, Modification, Redefinition) model proposed by Puentedura. Santos et al. (2019), showing a progression from technology as a direct substitute for traditional methods to technology as an enabler of previously unimaginable learning activities.

The teacher development trajectory is critical, evolving from technical problem-solving to strategic integration of digital tools to enhance pedagogical goals. This suggests that successful implementation of digitally assisted reciprocal learning

requires ongoing professional development that focuses not only on technical skills but also on pedagogical integration (Mishra & Koehler, 2006).

These findings extend the existing theoretical framework in several important ways. First, they provide an extension of Palincsar and Brown's (1984) original reciprocal learning model by showing how digital tools can enhance each of the four strategies. Digital highlighting and annotation tools appear to enhance summarization, online discussion forums facilitate questions, multimedia resources support clarification, and interactive features enable more sophisticated predictions.

Second, the results contribute to the growing understanding of new literacies in the digital age. Schünemann et al., (2013), showing how traditional comprehension strategies can be adapted and enhanced for digital contexts. Significant improvements across all dimensions of comprehension suggest that digitally assisted reciprocal learning can serve as a bridge between traditional literacy practices and the new literacies required in digital environments (Spörer et al., 2009).

Finally, the findings support the sociocultural perspective on literacy development. Vygotsky (1978) By highlighting how digital tools facilitate collaborative meaning-making and the social construction of knowledge through shared annotation, online discussion, and collaborative prediction (Nicholas et al., 2021). The development of group dynamics observed throughout the intervention period illustrates how technology can enhance the social dimensions of reading comprehension development. (Song et al., 2025).

Despite the robust findings, several limitations need to be considered. First, although the intervention duration (16 weeks) is longer than many similar studies, the long-term sustainability of effects remains uncertain. Second, the study was conducted in a relatively well-resourced educational context, which may limit generalizability to less resourced settings. Third, although the analyses account for baseline digital literacy levels, they do not fully explore how specific aspects of digital literacy interact with specific reciprocal learning strategies.

Future research should address these limitations through longitudinal designs that track the sustainability of effects, implementation studies in diverse educational contexts, and more detailed analyses of the interactions between specific digital competencies and specific comprehension strategies. Additionally, comparative studies that examine different approaches to technology integration in reciprocal learning would help identify the most effective combinations of pedagogical and technological elements.

## CONCLUSION

In conclusion, this study provides strong evidence that digitally assisted reciprocal learning is a promising approach to developing reading comprehension in elementary school students, especially for higher-order comprehension skills. The findings suggest that such an approach may be invaluable in narrowing the achievement gap, provided sufficient attention is paid to developing foundational digital literacy skills. As education systems increasingly prioritize digital competencies alongside traditional literacies, integrated approaches such as digitally assisted reciprocal learning offer a productive path forward.

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/0

PAGE 1

PAGE 2

PAGE 3

PAGE 4

PAGE 5

PAGE 6

PAGE 7

PAGE 8

PAGE 9

PAGE 10

PAGE 11

PAGE 12

PAGE 13

PAGE 14