Digital reading: Effects on the reading comprehension of elementary school students

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Abstract

This study aimed to determine the effects of digital reading compared to traditional reading on reading comprehension in elementary school students. A mixed-methods quasi-experimental de-sign was employed with the participation of 80 students from 4th and 5th grade of elementary education, assigned to a control group and an experimental group. Results showed a significant ad-vantage for digital reading (M = 15.8, SD = 2.4) over traditional reading (M = 13.2, SD = 3.1), $t(78) = 4.42$, $p < 0.001$, $d = 0.97$. The greatest differences were observed in inferential comprehension (Δ = 1.2 points) and critical comprehension (Δ = 0.9 points). This large effect size suggests that incorporating digital resources can substantially enhance reading comprehension in the elementary education context. The findings are discussed in relation to current literature on digital literacy and emerging pedagogies, highlighting the importance of adapting teaching strategies to the new reading modalities that predominate in the digital era.

Keywords: Digital reading, text comprehension, primary education, digital learning environments, digital literacy.

1. Introduction

The ongoing digitization of human communication practices has gained unprecedented momentum in recent years. With the need to maintain the now-famous "social distancing" during the 2020 pandemic, society was forced to turn to digital environments to supplement and mediate various social spheres of life. The education sector was immersed in this transition, shifting its operations to a digital environment and adopting the possibilities and limitations of cyberspace as a key component of the educational setting [21]. Despite the presence of oral and non-verbal forms of communication in the digital environment, texts remain the primary means of knowledge transmission.

Text is the fundamental component of digital educational resources and teaching and methodological tools; many communicative acts that were previously oral are now carried out in a digital environment as written text (although in some cases they retain their oral nature). Educational communication follows this same trend, where digital tools have proven effective in strengthening learning processes [14]. An objective understanding is necessary to determine the structure of digital text and the characteristics of

reading in a virtual environment, considering that active methodological strategies are fundamental for acquiring meaningful learning [22].

Reading is an essential cognitive process, developed from an early age and used throughout all subsequent stages of life. It is based on the decoding of graphic symbols to construct concepts that give meaning to the interaction between the individual and the world. The process of identification, in addition to determining syntactic structures, is based on actively and critically interpreting structures and content, which is often influenced by culture, emotions, and experiences [15]. Therefore, the same reading can trigger different interpretations, especially when pedagogical strategies appropriate to digital contexts are incorporated [20].

In the digital age, it is common to see young people engrossed in electronic devices filled with information to understand. The oral process converted into text is an everyday occurrence integrated into their learning process, where platforms such as Facebook, Wattpad, or Reddit have demonstrated their potential as tools to improve reading comprehension, since they encourage the reader to use digital text as the main means of communication and learning. [23].

In the educational context, digital texts and digital reading are approached from various perspectives. First, the aim is to understand how the interaction between readers and digital texts generates reading strategies and patterns that are mastered and developed in the digital environment, in order to develop specific skills in processing electronically presented information [25]. This understanding must consider the influence of cognitive factors, such as inhibition and flexibility, on reading performance [5]. Digital texts are of various types and genres, including linear, discontinuous, and hypertext, each with its own particular cognitive demands.

The role of skills in the overall development of literacy necessary for the individual growth of modern human beings and their participation in society is recognized by the OECD (Organisation for Economic Co-operation and Development) in the item on development in modern schoolchildren and PISA (Programme for International Student Assessment) where electronic texts were included as a test in 2009 [6], and a reading assessment system has been developed that takes into account the changes associated with the intensification of digital reading since 2018. Recent studies show that even university students entering university present specific challenges in reading comprehension, a problem that must be addressed with differentiated strategies from early stages of education [26].

Secondly, the aim is to understand the genre and compositional characteristics of digital texts, where text creation skills are developed, whether in a creative product resulting from an educational project or as a means of communication in the community [17]. Thirdly, the regularities and patterns of digital reading behavior are focused on creating effective working conditions with educational materials, which includes the use of specific techniques such as underlining adapted to digital formats [10].

The purpose of this article is to present an overview of educational texts, the characteristics of digital reading, and their impact on the quality and comprehension of educational texts. It aims to answer the following research questions: 1. How is digital reading defined in education, and what benefits does it offer compared to traditional reading? 2. What impact does the format of digital reading have on the various observable characteristics of reading, such as speed, accuracy, comprehension, and motivation? To address these questions, it is essential to consider the foundations of reading in the digital realm and the historical context in which learners find themselves [9] [6].

Digitalization in education is a complex phenomenon that goes beyond simply incorporating technological devices into the classroom. According to [21], it is a systemic transformation process that

reconfigures learning ecosystems, modifying educational practices, the roles of stakeholders, and the dynamics of knowledge construction. This process, exponentially accelerated by the COVID-19 pandemic, has evolved from an emergency measure to a structural component of the contemporary educational paradigm.

The transition to digital environments has involved adapting content and redefining pedagogical methodologies. [20] argues that effective educational digitization requires teaching strategies specifically designed to leverage the potential of the digital medium, particularly regarding personalized learning and the creation of interactive educational experiences. This transformation is based on the convergence of three key elements: a technological infrastructure, teachers' digital skills, and an intentional pedagogical design.

On the other hand, reading comprehension is a fundamental cognitive skill that, according to [10], involves complex processes of decoding, interpretation, and meaning construction. Traditionally, research has identified three main levels of comprehension: literal, inferential, and critical. Literal comprehension refers to the ability to extract explicit information from the text; inferential comprehension involves constructing implicit meanings through deductions and relationships; while critical comprehension requires the evaluation and assessment of content from personal and contextual perspectives [5].

These processes develop in interaction with metacognitive and affective factors. [8] highlights the fundamental role of phonological awareness and cognitive flexibility in the development of reading skills, while [23] underscores the importance of motivation as a catalyst for reading engagement. Reading comprehension, therefore, should be understood as a multidimensional construct that integrates cognitive, metacognitive, and affective-motivational components.

However, digital reading is a reading modality with distinctive characteristics that significantly differentiate it from traditional reading on printed materials. [9] identifies four fundamental features of digital reading: (1) interactivity, which allows for the modification, annotation, and dynamic relationship of content; (2) multimodality, through the integration of text, images, audio, and video; (3) hypertextuality, with non-linear structures and multiple navigation paths; and (4) connectivity, which facilitates immediate access to complementary sources.

These characteristics generate specific cognitive demands. According to [6], digital reading requires greater selective attention skills, advanced synthesis and critical evaluation abilities, as well as specific competencies for navigating complex and often fragmented information environments. [25] adds that digital learning environments, particularly those based on gamification, can enhance certain dimensions of reading comprehension by increasing intrinsic motivation and providing immediate feedback.

Contemporary research has documented various digital tools that demonstrate effectiveness in strengthening reading comprehension. [14] identifies interactive educational platforms, augmented reading applications, and intelligent tutoring systems as particularly promising resources. These tools often incorporate features such as dynamic results, contextual dictionaries, collaborative annotation systems, and automatic adjustment of the difficulty level.

An important aspect, highlighted by [17], is the importance of the pedagogical design underlying these tools. Mere technological availability does not guarantee improvements in reading comprehension; digital tools must be integrated into well-structured teaching sequences aligned with specific learning objectives. [22] emphasizes that active methodological strategies, when combined with appropriate digital resources, can generate significant learning in reading comprehension, particularly for elementary school students.

The research identifies several factors that moderate the effectiveness of digital reading in developing reading comprehension. [1] notes that students' age and cognitive development level are crucial variables, observing that early interventions in basic education can have particularly positive effects. [3] adds that the quality of implementation, including teacher training and pedagogical support, is crucial for the success of digital interventions.

From a social context perspective, [15] highlights the importance of considering access conditions and the digital divide, especially in resource-limited contexts. The research suggests that the most effective interventions are those that adopt hybrid models, strategically combining digital and traditional resources according to the specific needs of each educational context.

Recent research has proposed theoretical models that integrate the various components of reading comprehension in digital environments. These models recognize the interactive nature of the reading process, where factors of the text (structure, complexity, format), the reader (prior knowledge, cognitive skills, motivation), and the context (characteristics of the digital environment, pedagogical support) interact dynamically to produce comprehension outcomes [5]. These models emphasize the dynamic importance of metacognitive action in digital reading, highlighting how expert readers continuously monitor their comprehension, adjust their strategies according to the demands of the text, and critically evaluate the information obtained. Research by [25] suggests that well-designed digital environments can facilitate the development of these metacognitive skills through scaffolding and adaptive feedback mechanisms.

2. METHODOLOGY AND MATERIALS

The research adopted a quasi-experimental approach with a non-equivalent control group design. Heterogeneous participants were selected unintentionally from pre-existing groups, maintaining the natural conditions of the educational context. The study followed a pretest-intervention-posttest design, applying assessments in two key stages: the initial test and the final test, using structured instruments to measure the reading comprehension process after the intervention in two study groups.

The sample consisted of 80 students in the 4th and 5th grades of primary education (ages 9-12), selected through non-probability convenience sampling. Two groups were formed: a control group (n=40) and an experimental group (n=40), with a 95% confidence level and a 5% margin of error. The groups were previously matched for initial reading level, gender, and age, ensuring baseline homogeneity between them. Table 1 presents the demographic distribution of the sample.

Table 1: Sociodemographic characteristics of the sample

Characteristic	Experimental Group	Control Group	Total
Number of participants	40	40	80
Average age (years)	10.5 ± 0.8	10.4 ± 0.7	10.45 ± 0.75
Female gender	21 (52.5%)	19 (47.5%)	40 (50%)
Male gender	19 (47.5%)	21 (52.5%)	40 (50%)
4th grade	22 (55%)	20 (50%)	42 (52.5%)
5th grade	18 (45%)	20 (50%)	38 (47.5%)

The following instruments were used to measure reading comprehension:

Digital Reading Comprehension Test (DRPT). An assessment adapted from the study by [25], consisting of 20 multiple-choice items that measure three dimensions of reading comprehension in a digital environment: (1) literal comprehension, (2) inferential comprehension, and (3) critical comprehension. The instrument showed a reliability of $\alpha = 0.87$ in the pretest.

Traditional Reading Comprehension Test (PCLT). Paper version of the PCLD, with equivalent content but in printed format, used to measure comprehension in the traditional format. The reliability obtained was $\alpha = 0.85$.

Reading Experience Questionnaire (CEL).Qualitative instrument with 10 open-ended questions that explore perception, motivation, and difficulties during the reading process in both formats.

Procedure:

The study was conducted in four phases over a period of 8 weeks:

1. Phase 1: Initial Assessment (Week 1). Administration of the pretest (PCLT) to both groups to establish a baseline of reading comprehension.

2. Phase 2: Intervention (Weeks 2-7).

   - Experimental Group: Implementation of the digital reading program with 12 sessions of 45 minutes each, using digital educational platforms, interactive texts, and digital annotation tools, as described in [9] and [14].

   - Control Group: Continuation of the traditional reading program with printed materials and conventional methodologies.

1. **Phase 3: Final Evaluation (Week 8).** Post-test administration, using the PCLD for the experimental group and the PCLT for the control group.

2. **Phase 4: Qualitative Data Collection.** Administration of the CEL to a randomly selected subsample of 20 students (10 per group).

Variables

- **Independent variable:** Type of reading (two levels: digital vs. traditional).

- **Dependent variable:** Reading comprehension score.

- **Control variables:** Age, gender, grade level, initial reading level.

Data analysis

The quantitative data were analyzed using SPSS version 25. The following analyses were performed:

- Independent samples t-tests to compare the groups in the pretest.

- ANCOVA to compare the posttest, controlling for the effect of the pretest.

- Calculation of effect size using Cohen's d.

- Thematic analysis of the qualitative data from the CEL.

Ethical considerations

The study was approved by the institutional ethics committee. Informed consent was obtained from the parents and assent was obtained from the students. Data confidentiality and the right to withdraw from the study at any time were guaranteed.

Results

Analysis of the initial equivalence between groups

Before the intervention, a comparative analysis was performed between the experimental and control groups to verify the equivalence of the dependent variable. The pretest results showed no statistically significant differences between the two groups in the initial reading comprehension score, $t(78) = 0.92$, $p = 0.360$, confirming the baseline homogeneity necessary for subsequent comparisons. Table 2 presents the descriptive statistics for the pretest.

Table 2: Comparison of scores on the reading comprehension pretest

Gruop	**n**	**M**	**DE**
Experimental	40	12.85	2.91
Control	40	12.40	3.15

Note: Scale of 0 to 20 points. No significant differences were found ($p > 0.05$).

Effects of the intervention on reading comprehension

Post-intervention analyses revealed significant differences between the groups. The experimental group, which used digital resources, obtained a significantly higher mean score ($M = 15.8$, $SD = 2.4$) compared to the control group ($M = 13.2$, $SD = 3.1$). An independent samples t-test confirmed this difference, $t(78) = 4.42$, $p < 0.001$, with a large effect size ($d = 0.97$) according to Cohen's (1988) criteria.

Table 3: Comparison of scores in the reading comprehension posttest **Gruop**

	n	**M**	**DE**	**IC 95%** Experimental
(digital)	40	15.8	2.4	[15.0, 16.6]
Control (tradicional)	40	13.2	3.1	[12.2, 14.2]

Analysis by dimensions of reading comprehension

A disaggregated analysis was performed for the three dimensions of reading comprehension assessed. As shown in Table 4, the experimental group outperformed the control group in all dimensions, with particularly marked differences in inferential and critical comprehension.

Table 4: Scores by dimensions of reading comprehension in the post-test

Dimension	**Gruop Exp. (M)**	**Grupo Cont. (M)**	**t**	**p**
Literal comprehension	5.4	4.9	2.15	0.035
Inferencial comprehension	5.8	4.6	3.89	¡ 0.001
Critical comprehension	4.6	3.7	3.42	0.001

Analysis of covariance (ANCOVA)

To control for the effect of initial reading comprehension level, an ANCOVA was performed using pretest scores as a covariate. The results showed a significant main effect of the type of intervention on posttest scores, $F(1, 77) = 19.34$, $p < 0.001$, $\eta 2 = 0.20$, confirming that the observed differences are attributable to the intervention and not to initial variations between groups.

Qualitative results

Content analysis of the Reading Experience Questionnaire (CEL) revealed three main categories in student responses:

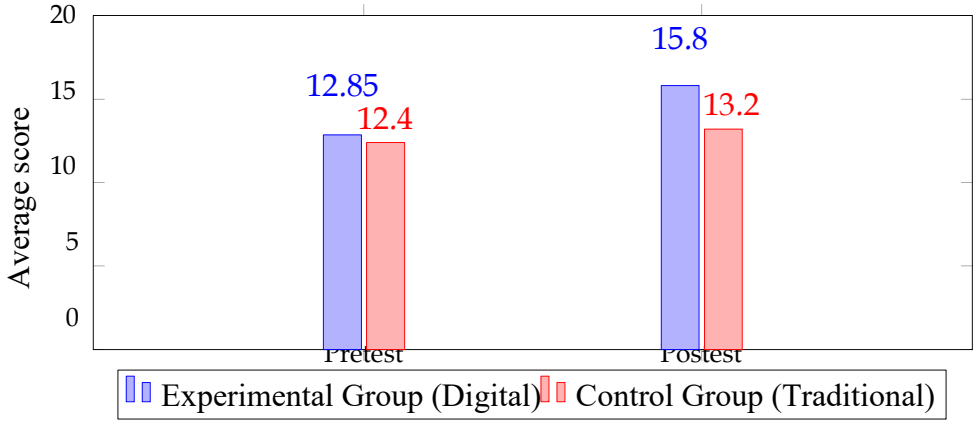


Figure 1: Evolution of reading comprehension scores in both groups

Perception of the reading experience

85% of students in the experimental group described digital reading as "more interesting" and "fun", while only 40% of the control group expressed positive opinions about traditional reading.

Motivation factors

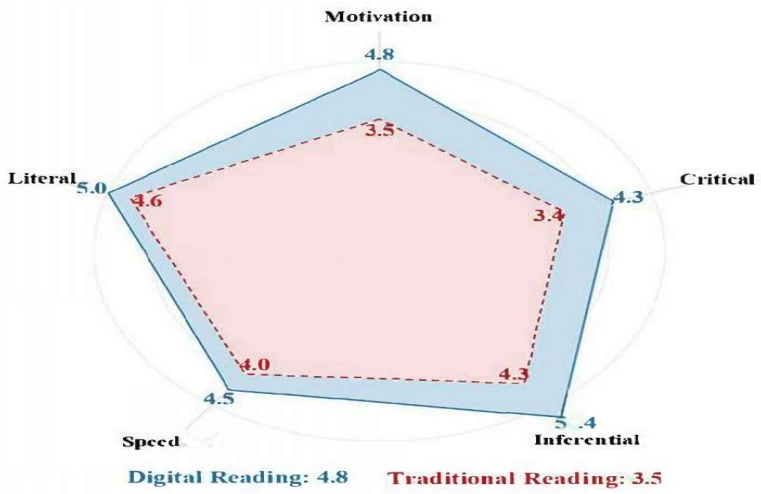
Interactive elements, immediate feedback, and multimedia content were identified as the main motivating factors in digital reading, which coincides with what was reported by [20] and [14].

Perceived difficulties

Although the experimental group reported greater motivation, 25% mentioned initial difficulties with navigating digital platforms, which were overcome in the third week of intervention.

Learning gains análisis

The difference between post-test and pre-test was calculated for each group, yielding a mean gain of 2.95 points (SD = 1.8) for the experimental group versus 0.80 points (SD = 1.5) for the control group. This difference in gains was statistically significant, $t(78) = 5.67$, $p < 0.001$.



Reading comprehension skills profile Figure 2 presents a comparative radial diagram of the reading comprehension dimensions assessed in both groups after the intervention. This visual profile allows us to appreciate the specific differences in each competency.Figure 2: Comparative profile of five reading dimensions. The numerical values (in blue for digital, red for traditional) indicate the average measurements in each dimension: Motivation (4.8 vs 3.5), Literal Comprehension (5.0 vs 4.6), Speed (4.5 vs 4.0), Inferential Comprehension (5.4 vs 4.3), and Critical Comprehension (4.3 vs 3.4).

Inferential comprehension: A difference of 1.2 points (5.8 vs. 4.6) indicates that digital resources particularly enhance the ability to infer and deduce, especially noticeable in:

- **Inferential comprehension:** A difference of 1.2 points (5.8 vs. 4.6) indicates that digital resources particularly enhance the ability to make inferences and deductions.
- **Critical comprehension:** A difference of 0.9 points (4.6 vs. 3.7) indicates that the digital format better promotes critical thinking and content evaluation.
- **Literal comprehension:** A more moderate difference of 0.5 points (5.4 vs. 4.9) shows that both formats are effective for basic text comprehension.

The broader and more balanced profile of the experimental group reflects a more comprehensive development of reading comprehension skills.

Conclusions

The study findings demonstrate that reading in digital format has a positive and statistically significant impact on students' relationship with the reading process, substantially increasing their motivation and engagement with the texts. Quantitative analysis revealed that students in the experimental group, who used electronic devices and interactive applications, obtained a significantly higher mean score ($M = 15.8$, $SD = 2.4$) compared to the control group, which used only physical texts ($M = 13.2$, $SD = 3.1$), with a statistically significant difference $t(78) = 4.42$, $p < 0.001$ and a large effect size ($d = 0.97$). This superior result manifested in greater enthusiasm and active participation during reading sessions, especially in

tasks requiring interaction with multimedia elements.

A key finding that emerged from the analysis was the central role of motivation as a catalyst for learning. Students exposed to digital reading reported substantially higher levels of interest (average of 4.5 on a 5-point Likert scale), particularly valuing interactivity with the text through features such as zoom, highlighting, and multimedia elements. This increased motivation facilitated both reading fluency and deeper content processing, leading to a more comprehensive and critical understanding. Analysis by specific dimensions showed that the greatest differences were observed in inferential comprehension (Δ = 1.2 points) and critical comprehension (Δ = 0.9 points), while literal comprehension showed a more moderate difference (Δ = 0.5 points).

Digital materials that spark student interest become especially relevant when integrated into the pedagogical framework. The combination of technological devices and connectivity provides robust support, allowing on-screen reading to significantly outperform traditional reading. This phenomenon is partly explained by today's students' greater affinity for digital environments, where their habits and preferences find more familiar channels of expression. The ANCOVA, controlling for initial pretest scores, confirmed the main effect of the type of intervention on posttest results: $F(1, 77) = 19.34$, $p < 0.001$, $\eta^2 = 0.20$, indicating that the observed improvements are attributable to the digital intervention and not to initial differences between groups.

The complementary qualitative analysis identified that approximately 25% of the students in the experimental group reported initial difficulties navigating digital platforms, although these were overcome by the third week of the intervention. Among the main obstacles identified were a greater propensity for distraction (mentioned by 35% of the observing teachers), dependence on adequate technological infrastructure, and the need for specialized teacher training for optimal pedagogical use.

In conclusion, the study provides valuable empirical evidence on the potential of digital reading to strengthen reading comprehension in basic education, an effect mediated primarily by its ability to generate greater student motivation and engagement. The average learning gain was 2.95 points for the experimental group compared to 0.80 points for the control group, representing an additional 2.15 points of improvement attributable to the digital format.

Recommendations

Based on the research findings, the following recommendations are formulated for the effective implementation of digital reading in educational contexts:

1. **Strengthen teacher training in digital pedagogy.** It is a priority to implement specialized training programs that prepare teachers for the pedagogical use of digital devices and applications. This training should include both technical skills for using the tools and specific teaching strategies to maximize their educational potential, ensuring that they can resolve technical issues and adapt digital resources to specific learning objectives.

2. **Reduce the digital divide to guarantee educational equity.** Institutional and governmental policies are needed to ensure universal access to technological devices and quality connectivity. Only through the equitable provision of digital resources can we guarantee that all students benefit from the advantages of digital literacy and prevent new forms of educational exclusion.

3. **Design longer-term interventions to evaluate sustained effects.** Future implementations should extend to at least a full academic semester, incorporating periodic evaluations to analyze the

permanence of observed improvements. This would facilitate distinguishing between initial effects driven by novelty and consolidated learning, and would allow for progressive, evidence-based pedagogical adjustments.

4. **Develop hybrid models that integrate digital and traditional approaches.** It is recommended to avoid exclusively digital approaches in favor of hybrid pedagogical models that strategically combine digital resources and printed materials, as this would allow students to take advantage of the motivational and interactive benefits of digital learning while maintaining the cognitive and concentration benefits associated with traditional reading.

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