

Reading Comprehension in the Digital Age: Integrating Cognitive Processes, Digital Literacies, and Emerging Technologies

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Abstract

Reading comprehension constitutes a foundational competence for meaningful learning, critical thinking, and active citizenship. In the current digital ecosystem, the act of reading has expanded beyond the printed page to encompass multimodal, hyperlinked, and interactive digital environments. This article synthesises contemporary theoretical frameworks and empirical evidence on reading comprehension, with a particular focus on the cognitive processes, digital literacies, and emerging technologies that shape comprehension in the digital age. Drawing on the active model of reading proposed by Duke and Cartwright (2021) and the construction-integration model of Kintsch (1998), the paper examines the interplay between automatic word recognition, vocabulary, inference generation, and executive functions. It further explores the distinctive demands of digital reading, including navigation, information integration, and critical evaluation of sources, alongside the potential of artificial intelligence and eye-tracking technologies to enhance instructional practice. The article concludes with evidence-based recommendations for educators, researchers, and policymakers to foster deep, critical, and equitable reading comprehension in an increasingly digital world.

Keywords: reading comprehension, digital reading, executive functions, multimodal learning, artificial intelligence, educational intervention

1. Introduction

Reading comprehension is far more than the mechanical decoding of written symbols; it is the active, strategic construction of meaning that integrates textual information with the reader's prior knowledge, experiences, and goals. As de la Peña (2026) observes, "*Comprender un texto es construir un modelo mental que representa lo que se ha leído, combinando información explícita e información implícita*" (p. 13). This constructive process underpins academic achievement, critical thinking, and autonomous learning across the lifespan.

In recent decades, the proliferation of digital devices and online information has transformed not only where and how we read, but also what it means to comprehend. Students today encounter a vast array of digital texts – from ebooks and hypertexts to social media posts, videos, and interactive infographics – often simultaneously. Yet international assessments such as PISA (OECD, 2024), PIRLS (Mullis & Martin, 2021), and NAEP (2022) consistently reveal that many students, even those who can decode fluently, struggle with deeper comprehension, particularly in making inferences and critically evaluating information. This persistent gap between basic reading skill and meaningful understanding underscores the urgent need for evidence based instructional approaches that address the full complexity of reading comprehension in both print and digital contexts.

This article aims to provide a comprehensive, research grounded overview of reading comprehension in the digital age by de-la-Peña (2026). Drawing on the theoretical model of Duke and Cartwright (2021) and the construction integration framework of Kintsch (1998), it reviews the key cognitive processes and skills involved in comprehension, including automatic decoding, vocabulary, inference generation, and executive functions. It then examines the specific demands of digital reading – navigation, multimodal integration, and source evaluation – and discusses the role of emerging technologies, such as artificial intelligence and eye tracking, in supporting comprehension. Finally, the article offers practical

recommendations for educators and researchers to promote deep, critical, and equitable reading comprehension across diverse educational settings.

2. Theoretical Foundations of Reading Comprehension

2.1. The Active Model of Reading

Contemporary reading science has moved beyond simplistic views of reading as a linear progression from word recognition to comprehension. Duke and Cartwright (2021) propose an active, dynamic model in which reading comprehension emerges from the synergistic interaction of multiple processes and skills, all of which are teachable and improvable. Their model organises these components into four interrelated domains: (a) word recognition processes (decoding, phonological awareness, visual recognition, orthographic knowledge); (b) bridging processes (vocabulary, reading fluency, morphological awareness, graphophonological semantic cognitive flexibility); (c) language comprehension processes (prior knowledge, literary knowledge, verbal reasoning, language structure, theory of mind); and (d) active self-regulation processes (executive functions, strategy use, motivation and engagement) (de la Peña, 2026, pp. 13–16).

Crucially, the model emphasises that comprehension is not a passive outcome but an actively constructed and monitored process. When one or more of these components are underdeveloped or poorly coordinated, comprehension suffers. However, all components are amenable to targeted instruction and practice – a central premise that underpins the pedagogical strategies presented in de la Peña's (2026) book (p. 16).

2.2. Levels of Text Representation: The Construction Integration Model

Kintsch's (1998) construction integration model provides a complementary framework for understanding the depth of comprehension. According to this model, readers move through successive levels of mental representation: (a) the surface level (literal identification of words and phrases); (b) the textbase (a propositional network of explicit ideas); and (c) the situation model (a deep,

integrated mental representation that incorporates prior knowledge, inferences, and contextual understanding) (de la Peña, 2026, pp. 16–18).

Research consistently shows that while most students perform adequately on literal comprehension tasks, they struggle to construct coherent situation models that require inferential and critical thinking. For example, students can typically answer factual questions (e.g., "What did Columbus discover?") but find it much harder to explain why a character acts in a certain way or to evaluate the implications of a text. This gap between literal and deep comprehension has profound implications for instruction: as de la Peña (2026) argues, educators must teach students not only to ask, "What does the text say?" but also "What does this mean?", "Why does this happen?", and "How does this relate to what I already know?" (p. 18).

3. Cognitive Processes and Skills in Reading Comprehension

3.1. Automatic Decoding: Freeing Cognitive Resources

Decoding – the ability to map graphemes to phonemes and blend them into words – is the foundational step toward comprehension. However, decoding must become automatic to be effective. When readers consciously labour over each word, they consume limited working memory resources that are needed for higher level processes such as inference and integration. As de la Peña (2026) notes, "*Una buena decodificación es una decodificación automática: rápida, precisa y sin esfuerzo consciente*" (p. 23).

Evidence from educational neuroscience indicates that expert readers process words visually and almost instantaneously, a capacity built through repeated exposure and systematic practice. Instructional strategies such as spelling exercises, word composition tasks, visual word shape recognition, and timed repeated readings have been shown to strengthen both the phonological and lexical routes to automaticity. De la Peña (2026) provides a weekly classroom routine for decoding practice – including hangman, spelling drills, chain word games, and digital mini games – that can be implemented in as little as five minutes per day (pp. 25–31).

3.2. Vocabulary and Prior Knowledge: Gateways to Meaning

Vocabulary and prior knowledge are among the most powerful predictors of reading comprehension. A rich, well organised lexicon enables readers to access word meanings quickly, infer unfamiliar terms from context, and connect new information to existing mental frameworks. Conversely, limited vocabulary constrains comprehension and perpetuates achievement gaps (de la Peña, 2026, pp. 33–34).

Effective vocabulary instruction goes beyond rote definition; it involves multiple exposures to words in meaningful contexts, explicit teaching of word learning strategies, and active use of new vocabulary in speaking and writing. De la Peña (2026) presents a range of practical activities – such as semantic family trees, Scrabble style games, category sorting, and concept circles – that engage students in deep processing of word meanings and relationships (pp. 36–40). Additionally, a weekly routine that includes word searches, word formation games, vocabulary bingo, and interdisciplinary word generation (Snow & Lawrence, 2011) has been shown to significantly enhance both vocabulary and comprehension (de la Peña, 2026, p. 40).

3.3. Inferences and Strategic Thinking: Reading Beyond the Lines

Inferences are the bridges that connect explicit text information with the reader's knowledge and experience, enabling the construction of a coherent situation model. Inference generation is one of the most powerful yet least explicitly taught comprehension skills. Research indicates that students generate more inferences when reading narratives than expository texts (Clinton et al., 2020), and that inference making mediates the relationship between prior knowledge and comprehension (Magliano et al., 2020).

De la Peña (2026) advocates for explicit instruction in inference strategies, including cause effect reasoning, intention detection, contextual inference, and coherence monitoring. Classroom activities such as detecting logical inconsistencies, solving mystery scenarios, completing open ended sentences, and comparing alternative text endings have been shown to strengthen inferential skills (pp. 45–49). A weekly routine that includes prediction tasks, pronoun resolution

exercises, context-based reasoning, and image-based inference generation can systematically build students' capacity to read between the lines (pp. 49–51).

3.4. Executive Functions: The Invisible Engine of Comprehension

Executive functions – including working memory, cognitive flexibility, inhibitory control, planning, and self-monitoring – are the cognitive control processes that regulate and guide reading. Verbal working memory allows readers to hold and manipulate phonological and semantic information simultaneously; graphophonological semantic flexibility enables rapid switching between word forms and meanings; inhibitory control helps suppress irrelevant information and resist interference; and planning and self-monitoring allow readers to set goals, anticipate difficulties, and adjust strategies in real time (de la Peña, 2026, pp. 53–55).

Decades of research have established that executive functions contribute uniquely to reading comprehension, above and beyond decoding and vocabulary (Cartwright et al., 2020; Nouwens et al., 2021). Importantly, executive functions are not fixed traits but can be trained through targeted activities. De la Peña (2026) proposes exercises such as "**word fishing**" (to foster cognitive flexibility), sentence expansion (to build working memory), reading planning (to develop metacognitive strategies), and "**mystery words**" tasks (to strengthen inhibitory control) (pp. 56–60). A weekly routine incorporating comprehension traffic lights, sentence ordering, taboo style games, and recall tasks can systematically enhance executive function in the reading context. Storytelling and shared reading, particularly from early childhood, are also powerful naturalistic interventions for executive function development (de la Peña, 2026, pp. 60–62).

4. Digital Reading Comprehension: New Demands and Opportunities

4.1. The Multimodal Nature of Digital Texts

Digital reading environments are inherently multimodal, combining written text with images, audio, video, and interactive elements. According to Mayer's (2009) cognitive theory of multimedia learning, comprehension in digital contexts depends on the integration of verbal and pictorial mental representations, which together form a richer, more complete situation model. Recent empirical studies have shown that the combination of audio and image significantly enhances digital reading comprehension compared to unimodal presentations (De la Peña et al., 2024a). However, not all multimedia elements are beneficial; irrelevant or distracting visuals, advertisements, and autoplay videos can impose extraneous cognitive load and impair comprehension (de la Peña, 2026, pp. 63–65).

4.2. Digital Literacies: Navigation, Integration, and Evaluation

Effective digital reading requires skills that go beyond traditional comprehension. The OECD (2021) identifies three core digital literacies: (a) navigation – the ability to move strategically through digital interfaces, manage hyperlinks, and adapt reading to purpose; (b) information integration – the capacity to synthesise content from multiple sources and formats into a coherent narrative; and (c) evaluation – the critical assessment of source credibility, bias, and evidential support (de la Peña, 2026, pp. 63–64).

Without explicit instruction in these skills, mere exposure to digital texts does not automatically improve comprehension. Indeed, meta-analytic evidence suggests that leisure digital reading has only a negligible effect on comprehension (Altamura et al., 2023), while print reading remains more strongly associated with deep understanding. De la Peña (2026) therefore advocates for systematic teaching of digital reading strategies, including purpose setting, hyperlink management, cross source comparison, and credibility checks. A weekly routine that involves comparing viral news with reliable sources, tracing information provenance, organising multimodal content into concept maps, and verifying data consistency can build these competencies incrementally (pp. 65–70).

4.3. Technology and Artificial Intelligence in Reading Instruction

Artificial intelligence (AI) is increasingly integrated into digital reading environments through virtual assistants, chatbots, adaptive learning platforms, and accessibility tools. Generative AI can produce customised text versions, summarise content, generate comprehension questions, and provide real time feedback, thereby personalising instruction and supporting diverse learner profiles. Recent meta-analyses indicate a moderate positive effect of generative AI on academic achievement and motivation, with stronger effects observed in primary education (Zhu et al., 2025). However, overreliance on AI for writing and summarisation may undermine critical revision skills, creativity, and autonomy (Veldhuis et al., 2025).

De la Peña (2026) emphasises that technology alone is insufficient; it must be accompanied by skilled teacher mediation, ethical use, and attention to accessibility (pp. 71–73). Tools such as Microsoft Immersive Reader, NaturalReader, Speechify, and C Pen Reader can support students with dyslexia, visual impairments, or language difficulties by offering text to speech, syllable segmentation, translation, and customisable display options (pp. 75–76). Eye tracking technology, meanwhile, offers real time insights into reading processes – fixation duration, regressions, and pupil dilation – enabling early detection of comprehension difficulties and the design of targeted interventions (De la Peña, 2024b, p. 76).

4.4. Multilingual and Inclusive Contexts

In increasingly diverse classrooms, many students are learning to read in a second or third language. Cummins' (2001) linguistic interdependence theory posits that strong L1 literacy skills positively transfer to L2 reading development. However, vocabulary and prior knowledge in the instructional language remain critical mediators. De la Peña (2026) recommends assessing comprehension in both L1 and L2, providing engaging reading materials in all languages, explicitly teaching L2 vocabulary, and adapting digital reading strategies to multilingual contexts (pp. 80–81). Multimodal tools – such as visual dictionaries, subtitled videos, and gesture-based activities – can bridge linguistic gaps and promote inclusive participation (pp. 71–72).

5. Future Challenges and Research Directions

The digital transformation of reading presents several interrelated challenges that demand interdisciplinary research and innovation. Key priorities include:

- **Deepening critical comprehension:** Moving beyond literal and inferential processing to foster critical evaluation, argumentation, and ethical reasoning in digital environments (de la Peña, 2026, p. 79).
- **Multimodal integration:** Understanding how different modalities (text, image, sound, video) interact to support or hinder deep comprehension and designing instructional sequences that optimise multimodal learning (p. 79).
- **Executive function and self-regulation:** Developing classroom-based interventions that systematically train executive functions – particularly working memory, cognitive flexibility, and self-monitoring – in the context of digital reading (pp. 79–80).
- **Equitable access:** Addressing the digital divide by ensuring that all students, regardless of socioeconomic background or disability, have access to appropriate devices, connectivity, and assistive technologies (p. 80).
- **Teacher professional development:** Equipping educators with the knowledge and skills to integrate digital reading strategies, AI tools, and multimodal pedagogies into their practice (p. 80).
- **Assessment innovation:** Designing authentic, process-oriented assessments that capture not only comprehension outcomes but also navigation patterns, source evaluation, and multimodal synthesis (p. 80).

Future research should employ ecological, longitudinal, and interdisciplinary approaches, leveraging digital trace data and eye tracking to capture the real time dynamics of digital reading. Such evidence will be essential for informing policy, curriculum design, and classroom practice that prepare students for meaningful participation in a digitally saturated world (de la Peña, 2026, pp. 81–82).

6. Conclusion

Reading comprehension in the digital age is both a continuation and a transformation of traditional literacy. It requires the same foundational skills – automatic decoding, rich vocabulary, inferential reasoning, and executive control – but extends them to encompass navigation, multimodal integration, source evaluation, and critical engagement with abundant, often fragmented, information. As de la Peña (2026) eloquently states, "*Comprender en la era digital no es solo leer más rápido, sino desarrollar pensamiento crítico, empatía y capacidad para construir sentido en medio de un océano de información*" (p. 83).

The evidence reviewed in this article underscores that reading comprehension is not an innate talent but a teachable set of skills that can be systematically developed through explicit instruction, practice, and mediation. The strategies presented – from decoding drills and vocabulary games to inference training, executive function exercises, and digital literacy routines – offer educators a practical, evidence-based toolkit for fostering deep comprehension in all learners. However, technology alone is not the solution; it is the teacher's professional judgment, human warmth, and pedagogical expertise that transform digital tools into powerful catalysts for learning (de la Peña, 2026, pp. 83–84).

Ultimately, the goal of reading education in the digital era must be to cultivate active, reflective, and critical readers who cannot only access and interpret information but also question, evaluate, and construct new knowledge. By integrating cognitive science, digital literacies, and emerging technologies within an inclusive, equity-oriented framework, educators, researchers, and policymakers can ensure that reading comprehension remains a cornerstone of meaningful, lifelong learning in the 21st century.

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