

CAPÍTULO I

CURRENT STATE OF KNOWLEDGE ON THE EFFECT OF AUGMENTED REALITY ON READING COMPREHENSION IN EARLY CHILDHOOD

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Abstract

The results of international assessments of reading comprehension show low performance among various population groups and suggest the need to develop new ways to encourage reading. Student-centered learning and digital transformation have incorporated augmented reality into textbooks to improve reading; however, its effect on processes such as text comprehension is still unknown. Therefore, the objective of this study was to analyze recent findings on the impact of augmented reality on reading comprehension in childhood. A systematic review was conducted, based on the post-positivist paradigm. Ten original studies developed using quantitative or mixed approaches were included. The search was carried out in the databases Scopus, SpringerLink, ScienceDirect, EBSCO, SAGE, Taylor & Francis, and in the PubMed search engine. It was found that augmented reality is associated with reading comprehension by positively impacting information processing and higher-order processes, such as monitoring and control. As a theoretical framework, some researchers based their findings on the Cognitive Theory of Multimedia Learning and classical theories. Future research is expected to control variables such as age, exposure time to augmented reality, and participants' behavioral aspects. Likewise, longitudinal studies are recommended to analyze the novelty effect of augmented reality on learning achievement and retention.

Keywords: augmented reality, reading comprehension, new technologies.

ESTADO ACTUAL DE CONOCIMIENTO SOBRE EL EFECTO DE LA REALIDAD AUMENTADA EN LA COMPRENSIÓN LECTORA EN LA ETAPA INFANTIL

Resumen

Los resultados de evaluaciones internacionales sobre comprensión lectora evidencian bajo desempeño en diversos grupos poblacionales y sugieren desarrollar nuevas formas para incentivar la lectura. El aprendizaje centrado en

el estudiante y la transformación digital han incorporado la realidad aumentada a los libros de textos para mejorar la lectura, sin embargo, no se conoce su efecto en procesos como la comprensión de textos. Por ello, el objetivo del presente estudio fue analizar los hallazgos recientes sobre el impacto de la realidad aumentada en la comprensión lectora en la infancia. Se realizó una revisión sistemática, sustentada en el paradigma postpositivista. Se incluyeron 10 investigaciones originales desarrolladas desde el enfoque cuantitativo o mixto. La búsqueda se realizó en las bases de datos Scopus, Springer link, Sciencedirect, Ebsco, Sage, Taylor & Francis y en el buscador Pubmed. Se identificó que la realidad aumentada se asocia con la comprensión lectora al impactar positivamente procesos de registro de información y superiores, como el monitoreo y el control. Como referente teórico, algunos investigadores fundamentaron sus hallazgos en la teoría cognitiva del aprendizaje multimedia y teorías clásicas. Se espera que futuras investigaciones controlen variables como la edad, el tiempo de exposición a realidad aumentada y aspectos conductuales de los participantes, así mismo, se espera que las investigaciones sean longitudinales para analizar el efecto de la novedad de la realidad aumentada en el logro y permanencia del aprendizaje.

Palabras clave: realidad aumentada, comprensión lectora, nuevas tecnologías.

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Introduction

Reading comprehension (RC) is a skill associated with good academic performance and successful social and professional adjustment. It is also a transversal competence for acquiring new knowledge in different areas. Despite its importance, performance remains low, especially in developing regions. According to a report by the World Bank Group (2022, p. 17) on the impact of the COVID-19 pandemic on academic outcomes in Latin America and the Caribbean, “four out of five sixth-grade students are expected not to reach the minimum level of reading comprehension.” Consistent with this, the results of the Programme for International Student Assessment (PISA, 2022) show a significant decline in reading performance between 2018 and 2022 in all OECD (Organisation for Economic Co-operation and Development) countries.

To transform this situation, educators and researchers have implemented strategies based on new technologies to overcome traditional pedagogical practices and promote motivation and deep learning among students (Kanobel & Arce, 2019; Ledesma & Villaverde, 2019). Accordingly, there is evidence of the effect of augmented reality (AR) on motivational aspects (Ruijia et al., 2025) and learning gains (Garzón et al., 2019; Roberto et al., 2024). More specifically, evidence has been found regarding the effect of AR on language skills (Silverman et al., 2024) and reading efficiency (Du et al., 2024).

Researchers have also pointed out disadvantages in the implementation of AR in the classroom, such as increased cognitive load (Buchner et al., 2022) and negative effects on educational inclusion, since not everyone has access to these technologies (Garzón et al., 2019). Regarding AR books, Munzer et al. (2019) indicate that they may be cognitively demanding due to the multiple stimuli to which readers are exposed, and may interfere with parental or teacher scaffolding, thus reducing comprehension in young readers.

With respect to systematic reviews on the effect of AR on RC, a documentary study by Roberto et al. (2024) was identified. Their analysis focused on categories such as the impact of AR on RC in second-language learning and AR and reading for inclusive education. The findings were broad and heterogeneous, addressing various aspects of reading without providing consistent evidence of the effect of AR on the RC process. Therefore, the objective of this study was to analyze empirical evidence on the effect of augmented reality on reading comprehension in children. Understanding the current state of knowledge on the effectiveness of AR in RC will support evidence-based educational actions in teaching methodologies and didactics aimed at improving reading comprehension in childhood. Likewise, identifying methodological and procedural aspects of existing research will contribute to the development of more robust studies that positively impact pedagogical practice.

In general terms, this review focuses on the following questions: What is the impact of AR-supported reading on RC? What are the methodological and procedural characteristics of the interventions conducted? What theoretical model guided the research and/or which cognitive processes are associated with better RC performance?

Theoretical Framework

Due to the complexity of reading and constructing meaning from texts, theoretical discussions are broad and complementary, especially those based on cognitive psychology principles. This perspective assigns an active role to the reader in text comprehension, assumes the existence of different processing levels, and highlights the bidirectional interaction between prior knowledge and text structure.

Within this broad and heterogeneous debate, the Construction–Integration (C–I) model proposed by Kintsch (1998) stands out. This model emphasizes that mental representations of what is read are achieved through C–I mechanisms. Accordingly, reading comprehension corresponds to a sequence of mental states mediated by cycles of meaning construction and reconstruction, involving different levels of cognitive processing. These include word identification, recognition of syntactic and semantic relationships, interaction between textual

information and prior knowledge, and finally, the generation of a mental representation of the text. In the search for strategies to promote RC, new technologies such as AR emerge as innovative and motivating possibilities for students. According to Santi et al. (2021), AR is a technology that overlays a “virtual” object (symbol, image, text) onto a real-world video or graphic display in real time. These technologies contribute to literacy development and may include audio, interactive simulations, animations, and 3D graphics that are activated by holding an electronic device (cell phone or tablet) over printed pages (Danaei, 2020).

The integration of new technologies into education involves the challenge of understanding information processing mediated by technological or artificial intelligence tools. In this context, the Cognitive Theory of Multimedia Learning proposed by Mayer (2005, as cited in Mayer & Fiorella, 2021) emerges. This theory states that people learn from multimedia instructional messages, which consist of multisensory stimuli that promote meaningful learning by integrating and organizing materials with prior knowledge into a coherent cognitive structure (Lai et al., 2019).

Based on the above, it can be inferred that the Cognitive Theory of Multimedia Learning shares assumptions with the C-I model proposed by Kintsch (1998), since both consider the learner an active processor of information. Both assume that coherent mental representations are generated through stimulation (text or images) by integrating prior knowledge. In this sense, these theories can complement each other in analyzing the reader’s cognitive processing when reading activities are mediated by technological tools such as AR.

Methodology

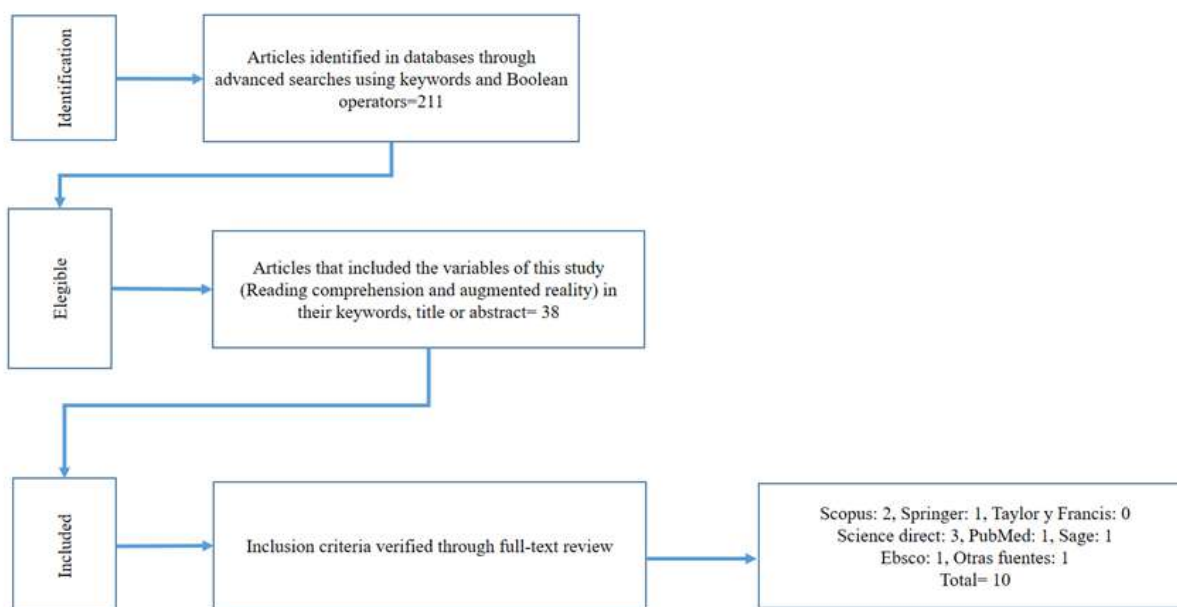
The present study is a systematic review grounded in the post-positivist paradigm, which conceives knowledge as an approximation to reality that must be constantly questioned and renewed (González & Mercado, 2023). According to Arias Odón (2023), a systematic review aims to describe what and how a topic has been studied and what remains to be investigated. In this case, it seeks to examine what has been researched regarding the effect of reading augmented reality (AR) books on reading comprehension (RC) in children. Original research articles developed using quantitative or mixed methodologies, through pre-experimental or quasi-experimental designs, were included. No time restrictions were applied to the search. The following descriptors were used: ("augmented reality" OR "AR technology") AND ("reading comprehension" OR "text comprehension") AND ("primary school" OR "elementary school" OR "primary education"). Articles focused on disability and second-language learning were excluded.

Procedure

The search for articles was conducted in the databases Scopus, SpringerLink, Taylor & Francis, ScienceDirect, SAGE, EBSCO, and the PubMed search engine. Using advanced search options, it was specified that the descriptors had to appear in the title, keywords, or abstract. Only Open Access journal articles were selected. Additionally, Google Scholar was used to identify supplementary sources. The results of the search process are summarized in Figure 1.

Figure 1.

Article Selection Process



Source: Authors' own elaboration (2025).

Results

The results were organized according to the research questions. Regarding the impact of AR-supported reading on reading comprehension, 90% of the studies reported better RC performance in experimental groups—that is, in students who read AR books and in those who had greater exposure to AR (Table 1). Some authors indicated that AR-supported reading improved implicit or inferential comprehension compared with traditional texts. However, no significant differences were found between the two groups in terms of literal comprehension (Du, 2024; Liu, 2024; Şimşek & Direkçi, 2023).

With respect to the methodological characteristics of the studies, researchers mainly implemented quasi-experimental designs. Eighty percent of the studies were conducted in Asian countries (Turkey, China, and Iran), and 20% in the Americas (the United States and Colombia).

Table 1.
Characteristics of research designs and conclusions

Author	Research Design	Sample	Conclusions
Annetta et al. (2024)	Mixed methods, convergent design.	24 fifth-grade students USA	RC improved in the group exposed to mixed reality (MR).
Bursali & Yilmaz (2019)	Quasi-experimental	89 fifth-grade students aged 10–11	Students who read using AR materials performed better in RC than those using traditional methods.
Danaei et al. (2020)	Quasi-experimental	34 children aged 7–9 from five children’s libraries in Tehran, Iran	RC was higher in the group that read AR books.
Du et al. (2024)	Quasi-experimental	60 second-grade students in China	Students using AR storybooks showed better implicit RC but not explicit RC.
Liu et al. (2024)	Quasi-experimental	80 second-grade students from two rural schools in China (average age: 7.5)	The experimental group outperformed the control group in implicit questions across three tests.
Özdemir & Akyol (2021)	Quasi-experimental	54 fourth-grade students in Kars Province, Turkey	Significant differences in RC scores favored the experimental group.
Şimşek & Direkçi (2023)	Quasi-experimental	120 students aged 11–12 in Antalya, Turkey	No difference in literal comprehension between groups, but differences found in reorganization and inference.
Şimşek (2024)	Quasi-experimental	90 children (average age: 54.2 months)	Significant differences in story comprehension favored the experimental group.
Şimşek et al. (2025)	Quasi-experimental	134 students aged 11–12 in Antalya, Turkey	AR storybooks improved RC in 11–12-year-olds, but exposure duration should be considered.
Tobar-Muñoz et al. (2024)	Design-based research	51 third- to sixth-grade students in Colombia	No significant differences in RC between control and experimental groups.

Note: EG = Experimental Group; CG = Control Group; RC = Reading Comprehension; AR = Augmented Reality; MR = Mixed Reality.

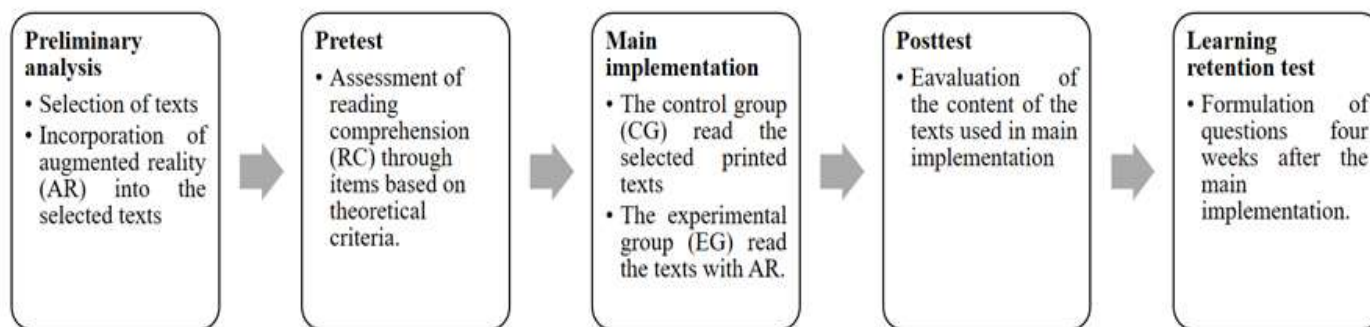
Source: Authors’ own elaboration (2025).

Most researchers followed five phases to achieve the study objectives, as shown in Figure 2. In the preliminary analysis, they selected reading materials according to the participants’ age and cultural background and verified the academic and technological relevance of the materials with the support of classroom teachers and technology specialists. Some researchers conducted pilot studies to assess the level of difficulty of the materials and to familiarize participants in the experimental group (EG) with the characteristics of augmented reality (AR). During the pretest phase, participants in both groups (EG and control group [CG]) read printed

texts or completed standardized tests. In the main implementation phase, the CG read printed texts, while the EG read AR-supported texts. In some studies, participants read individually; in these cases, each student had an electronic device for AR reading (Du et al., 2024; Şimşek et al., 2025; Danaei et al., 2020; Şimşek & Direkçi, 2023). In other studies, reading was conducted in pairs or with the whole group. In the latter case, printed or AR texts were projected onto a board (Liu et al., 2024; Bursali & Yilmaz, 2019; Tobar-Muñoz, 2017), or the teacher read the AR texts using a tablet (Şimşek, 2024). In the posttest phase, questions related to the main implementation were administered. Some authors evaluated reading comprehension according to performance levels: literal or explicit, and inferential or implicit (Du et al., 2024; Liu et al., 2024; Şimşek & Direkçi, 2023; Tobar-Muñoz, 2017). Only a few studies included a phase to assess learning retention (Bursali & Yilmaz, 2019).

Figure 2.

Research implementation procedure



Note: Abbreviations: EG = Experimental Group; CG = Control Group; RC = Reading Comprehension; AR = Augmented Reality; MR = Mixed Reality.

Source: Authors' own elaboration (2025).

The final question of this review concerns the theoretical foundations adopted by researchers. Authors such as Du et al. (2024) and Liu et al. (2024) based their findings on the Cognitive Theory of Multimedia Learning. Other authors (Du et al., 2024; Danaei et al., 2020) used multisensory learning as their theoretical foundation. Şimşek and Direkçi (2023), in turn, adopted Clark et al.'s (2014) theory of reading comprehension development as their framework. From a constructivist perspective, Tobar-Muñoz (2017) stated that reading processes should be based on social interaction and play.

Discussion

The purpose of this review was to analyze recent findings on the impact of augmented reality (AR) on reading comprehension (RC) in childhood. Ten studies met the inclusion criteria. It was observed that 90% of the studies reported that AR had a statistically significant effect on RC. However, it is likely that other variables such as the type of instruction or procedure, the novelty effect of technological media, and the duration of exposure to AR, may have influenced the results. Regarding procedural aspects, authors such as Liu et al. (2024) allowed participants to discuss guiding questions, a strategy that may have influenced the findings through the principles of dialogic pedagogy (Maine, 2024). In contrast, Tobar-Muñoz et al. (2017), who found no significant differences between the control group (CG) and the experimental group (EG) in reading performance, indicated that their results might have been associated with low instructional control within the working groups. They reported “negative actions” by participants, such as not reading the book or failing to follow instructions. In the same study, researchers incorporated games to promote learning, which may have exceeded students’ cognitive resources and affected reading outcomes. According to Lai et al. (2019), instructional designs should identify total cognitive load to ensure that it does not exceed working memory capacity. Furthermore, the use of novel technological media may have a positive impact on readers’ motivation, especially in children (Bursali & Yilmaz, 2019). However, positive attitudes toward such interventions may fade over time (Makransky et al., 2019), which may consequently reduce their effect on RC. With regard to time-related variables, Şimşek et al. (2025) found that very short or very long experiences may increase cognitive load and affect readers’ attentional processes.

In light of the above, further research on the effect of AR on RC is needed, incorporating variables related to instructional design (exposure time to AR, instructional design), context (school climate), students (motivation, self-efficacy, levels of participation, school climate, etc.), and teachers (participation in design, digital competence, etc.), as these factors may influence outcomes.

The second research question focused on methodological aspects. It was observed that quasi-experimental or design-based studies allowed for comparisons between traditional textbooks and AR-enhanced textbooks in RC, providing evidence in favor of AR materials, in line with Du et al. (2024). However, longitudinal studies are required to determine whether these effects depend on the novelty associated with new technologies and whether learning outcomes are sustained over time. Moreover, despite the scope and evidence supporting AR, its use remains limited to developed or industrialized countries such as China and Turkey, where projects promoting technological infrastructure are encouraged (Tarman et al., 2019) and where digital technologies are

widely implemented across sectors, including education (Feijóo et al., 2021). This suggests that limited access to technological resources, low connectivity, and insufficient digital skills training for students and teachers in developing countries may increase educational inequalities, as noted by García Sagrado (2025).

Regarding procedural aspects, some authors verified the academic and technological relevance of materials through evaluations by teachers and designers, which is essential for strengthening the adoption of new tools in the classroom. According to De Lima et al. (2022), despite the large number of AR studies, classroom implementations remain limited because research often focuses on learning outcomes while neglecting technical aspects, such as teachers' active participation in design. Therefore, teachers must develop digital competencies for designing and implementing new classroom strategies (Ledesma & Villaverde, 2019).

Finally, regarding how AR affects cognitive processing in reading tasks, some studies (Du et al., 2024; Danaei et al., 2020) suggested that its effect results from multisensory stimulation, combining text with images, 3D graphics, and/or voiceovers to support information encoding through different sensory systems (bottom-up processing). However, it is important to examine whether sensory processing is directly related to comprehension or whether it mainly supports other learning-related processes, such as motivation. Evidence shows that illustrations in children's storybooks do not significantly affect reading comprehension but do influence book selection decisions (Sun, 2023). From another perspective, Lu et al. (2022), Şimşek and Direkçi (2023), Liu et al. (2024), and Tobar-Muñoz et al. (2017) reported significant differences in inferential comprehension. Therefore, AR-enhanced illustrated books that include strategies such as interactive questioning may facilitate the understanding of more abstract and complex content, as well as monitoring and control processes (Alhamad et al., 2024). It is also expected that instructional designs may provide immediate conceptual support, which would promote RC through vocabulary acquisition, as suggested by other studies (Rodrigues et al., 2022).

Conclusions

Data analysis indicates that AR has positive effects on reading comprehension, likely due to its impact on bottom-up processing (multisensory reading) and higher-order processes such as monitoring and control through questioning and concept activation. This study also contributed information on research procedures in this field, highlighting the use of cross-sectional quasi-experimental designs. Future research is expected to adopt longitudinal approaches and control variables related to instructional design, students, teachers, and context that may influence outcomes. It is also important to conduct studies with participants of different ages, as visual and auditory stimulation may support vocabulary acquisition, decoding, and memory capacity in

younger learners. However, the impact of AR on cognitive processing in older students remains unclear. Finally, these conclusions should be interpreted with caution, as only Open Access studies were reviewed, which may result in partial conclusions about the current state of knowledge. Moreover, given the descriptive scope of this study, the findings may serve as a reference framework for future research.

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