Digital reading comprehension: multimodal and monomodal inputs under debate

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In today's digital context, it is essential for students' academic and personal development to improve their digital reading comprehension. A comparative analysis of digital reading comprehension between three modalities is presented: dual (multimodal), auditory, and visual (monomodal). We used an experimental design and a standardized test (PROLEC-SE -R) of reading comprehension administered to 132 secondary school students in their first language. The quantitative analysis, which considered age, gender, and academic achievement, shows that there are significant differences in favor of dual modality or multimodality in digital reading comprehension. This shows that multimodality improves the level of digital reading comprehension the most. In particular, there is a significant difference in favor of the literal level of digital reading comprehension compared to the inferential level in all modalities studied (dual, auditory, visual). This yields pedagogical implications for optimizing digital reading comprehension.

Keywords: reading comprehension; digital reading; multimodality; monomodality.

Introduction

Reading comprehension is a competency that must be developed in all students to achieve quality education, according to the current Sustainable Development Goals (SDG) of the 2030 Agenda. Furthermore, the Official Journal of the European Union (2018) highlights the importance of improving the level of digital literacy at all levels of education. To this end, teachers and policy makers should develop practices adapted to societal change to optimize the acquisition, development, consolidation, and critical use of reading comprehension in a digital context. International studies on reading comprehension indicate the need to improve this competency at the primary and secondary levels, considering the results of international assessments (Mullis & Martin, 2021). When reading and even listening comprehension are low, academic performance

tends to be correspondingly poor (Cox et al., 2014).

As a result of the COVID -19 pandemic, online education became mandatory worldwide. Education professionals were required to acquire digital literacy skills to successfully teach their students in an e-learning environment. To track students' reading, traditional print reading was replaced by digital reading in many countries (Støle et al., 2020). When a text is digitized, users access and interpret information in various formats (e.g., apps, social networks, etc.) (Khun et al., 2022). Today's students are faced with an environment full of visual and digital multimodal texts. Therefore, the transition from reading on paper to reading on screen brings new comprehension demands as the reader is confronted with multiple rapid and multimodal data sources. In addition, today's teens, who are considered digital natives (Prensky, 2010), are familiar with reading on screen (Kress, 2003) and dealing with multimodality. As students are immersed in a digital environment and digital reading is therefore increasing (Ross et al., 2017), activities and educational tasks should also be presented in a digital format (Wu & Chen, 2018). In this sense, digital and print reading comprehension coexist in the classroom for academic success. Digital reading comprehension is dynamic and requires, on the one hand, the same cognitive processes as print reading comprehension and, on the other hand, specific skills for non-linear navigation, search, and evaluation of information (OECD, 2021). This digital reading comprehension can start from a monomodal text, which involves a more inductive reading based only on linguistic elements, or from a multimodal text, which is more deductive because the reader is confronted with linguistic, visual, and semiotic elements, with more friendly information (Vera, 2015). Research (Guo et al., 2020; Mayer, 2009) shows that multimodal presentation of information enriches digital reading comprehension. In this digital age, the use of specific digital resources is a must, and multimodal texts could

improve reading comprehension in different educational levels. Therefore, this research aims to respond to the pedagogical need to improve reading comprehension in a digital environment. To this end, we propose a comparative study of reading comprehension outcomes in different modalities: auditory, visual, or dual (both auditory and visual in a video format). In this way, based on scientific evidence, we will provide an answer to the inconsistency of previous data and open a new field of research for the formative development of digital reading comprehension in the classroom. This leads to the following questions: Which modality is most conducive to students' digital reading comprehension? Are there differences between the levels of literal and inferential reading comprehension in the different digital modalities?

Multimodal and monomodal digital reading comprehension

In this digital education context, students need reading strategies and navigation skills to deal with digital texts (Hahnel, 2017). Research focuses on comparing digital and print reading comprehension and comes up with contradictory results in favor of the digital format (Clinton, 2019; Clinton-Lisell, 2021), against the digital format (Kazazoglu, 2020; Schwabe et al., 2021), and no differences between the two formats (Alisaari et al., 2018). On the one hand, proponents of the digital format emphasize the organization and relevance of the content as an aid to deeper reading comprehension (Shi et al., 2020). On the other hand, critics of the digital format point to superficial reading comprehension and lower performance compared to the print format due to slanted reading (Baron et a., 2017) and difficulty concentrating due to high cognitive load according to superficiality theory (Annisette & Lafreniere, 2017). However, in a digitized environment where, according to Wu & Chen (2018), most institutions use digital texts for instructional content and activities, we need to examine which digital modalities can benefit digital reading comprehension and overcome the criticisms of the

digital format.

In this scenario, digital reading comprehension can be monomodal (when only one type of sensory modality is used to process the information in the written text) or multimodal (when at least two types of sensory modalities are used to process the information in the written text).

In the study of monomodal digital reading comprehension, one can start from Kintsch's (1998) situational model of comprehension, which considers the input of only one type of information, preferably verbal as used in this study (auditory and visual modality), and in which reading comprehension is based on a mental representation derived from the textual information or a mental model. In the first case, a mental representation is created that accesses the semantic level (explicit data) to give coherence to the text, which is a more literal or surface level of reading comprehension of the information (construction); and in the second case, a mental representation is created that accesses a mental simulation of the situation (explicit data plus implicit data) in which the text is embedded, which corresponds to a more inferential or deeper level of reading comprehension (integration) involving prior knowledge and experience (van den Broek et al., 2016). In recent years, studies (De-la-Peña & Luque-Rojas, 2021; Del Pino-Yépez et al., 2019; Lah & Hashim, 2014; Sufa et al., 2023) have identified these levels of reading comprehension (literal or surface and inferential or deep reading comprehension) and demonstrated better performance in students at the level of literal versus inferential reading comprehension. As for monomodality, visual literacy deals with “the symbolic aspects upon which messages are based" (Januarty & Nima, 2008, p. 16). It can be defined as the ability to infer, analyze, evaluate, and communicate information that is cognitively appealing to the reader (Chauvin, 2003) and whose meaning is derived from the temporal sequence of the written text (Kress, 2010). Aural

literacy refers to understanding of a text by listening to it without reading it. Listeners typically cannot listen to a text again, whereas readers using the visual modality can read a paragraph as many times as necessary. Therefore, attention and memory skills are important in auditory literacy (Wolf et al., 2018). In studying multimodal digital reading comprehension, it is necessary to start from Mayer's (2009) Cognitive Theory of Multimedia Learning (CTML) model. This theory states that text representation is a combination of verbal and pictorial mental representation, with processing occurring simultaneously in both information channels. This multimodal digital reading comprehension implies that students actively generate a mental representation of the written text that integrates key visual and verbal aspects, thus promoting the construction of the deep meaning of the information (Mayer, 2009). Multimodal literacy refers to understanding discourse by creating meaning when different modalities interact in a text (Eksi & Yakisik, 2015). Multimodal texts offer a range of sensory modes that work synchronously to convey meaning (Mayer, 2014). They are inherently linked to information and communication technologies as digital texts come together with different auditory, visual, gestural, spatial, and linguistic modalities (Januarty & Nima, 2018). The use of multimodal texts enhances students' creativity, participation, production, and attention (Callow & Zammit, 2012) and also changes the nature of different language skills (Walsh, 2010). They can be a combination of spoken and written language and with still or moving images (Walsh, 2006). The different modalities of a text add meaning to the text itself (Cortiana, 2017) and can bring further benefits to students with low language proficiency (Wood et al., 2018), who do not master the target language, or who have hearing problems (Irdamurni et al., 2020). However, they can also bring disadvantages because, as Jiménez-Pérez et al. (2017) argued, the more stimuli present in a multimodal text at the visual level, the more likely

the reader is to be distracted. In this study, dual literacy (auditory and visual literacy in the form of videos) is considered multimodal literacy in which the reader is presented with more than one modality.

Several researchers have investigated the relationship between multimodal texts and reading comprehension. Son (2003) studied the paper format, computer-based non-hypertext forms, and computer-based hypertext format and found that students comprehended better when the texts integrated sound and images (dual multimodality). Chun and Plass (1996) argued that multimodal texts, especially videos, facilitate reading comprehension. Kuo et al. (2010) and Barahani and Ghafournia (2015) examined the effects of multimedia on reading comprehension and found that students improved their comprehension when they read multimodal digital texts rather than monomodal digital texts. Liu (2013) studied the effect of visual images in multimodal texts and argued that they provide additional information and enhance reading comprehension. Serafini (2010) also examined multimodal texts, particularly those found in picture books (combining images and text), and Januarty and Nimia (2018) examined the frequency of multimodal text use in Indonesia. Both studies concluded that their use is quite common. However, neither of these studies showed which modality had a greater impact on reading comprehension. Besides, Rogowsky et al. (2016) demonstrated poorer reading comprehension in adults when the dual modality was used, and furthermore, opaque (such as English) and transparent orthographic languages (such as Spanish) may unfold different effects of dual modality on reading comprehension (Kwok et al., 2017). Meneses et al. (2018) showed no significant differences in reading comprehension between different multimodal science texts in Chilean fifth graders in elementary school. In the field of foreign language acquisition, dual modality (reading and listening, as is common with audiobooks) has been shown to be efficient in terms of

reading comprehension, reading fluency, and lexicon acquisition (Chang & Millet, 2015). Vera (2015) demonstrated that multimodal texts improve students' reading comprehension of narrative texts in English as a foreign language (hereafter EFL) compared to monomodal texts because the different elements in the multimodal version help students construct meaning. Kress (2003) found that there are differences in multimodal reading in terms of age and genre, among other factors, and Álvarez-Alonso et al. (2021) found differences in terms of genre among secondary students.

There is a need to investigate how each digital modality affects reading comprehension because digital reading is part of daily life and the educational environment, so educational policy must target the effectiveness of the most proficient modalities in reading comprehension. The results of this study will provide evidence that can help teachers and parents make decisions about selecting digital multimodal resources that significantly improve students' reading comprehension. This reading comprehension is the foundation for the OECD (2021) to acquire the formative learning needed for comprehensive development, and digitization can be used as a tool to develop this linguistic competence in line with the SDGs of the 2030 Agenda.

Methodology

Objectives and hypotheses

This research aims to understand the specific type of digital modality that most improves secondary students' reading comprehension. Most of the work (Barahani & Ghafournia, 2015; Kuo et al., 2010; Vera, 2015) shows that dual modality provides better reading comprehension compared to other monomodal forms of information input, such as auditory or visual. Moreover, the current scientific literature (De-la-Peña & Luque-Rojas, 2021; Del Pino-Yépez et al., 2019) shows that performance on literal

versus inferential reading comprehension tasks is better at a general level, although no differences were found between the different modalities of information input. Therefore, based on the aforementioned objective and the review of the scientific literature, the hypotheses are operationalized:

- Null hypothesis (H0): There are no differences in reading comprehension depending on the type of information input modality.
- Alternative hypothesis (H1): There are differences in reading comprehension depending on the type of information input modality in favor of the dual modality.
- Alternative hypothesis (H2): There are differences between the literal and inferential levels of reading comprehension in the three digital modalities.

Design

This study is an experimental design with an objective measurement of the dependent variable (reading comprehension), a quantitative analysis of the information with a measurement, a manipulation of the independent variable (modality type), and a random assignment of students to each modality (Maciejewski, 2018). Specifically, it corresponds to a simple intergroup design with a post-treatment measurement.

This work is part of the outcome of a research visit to the University of Malaga in the academic year 2022-2023, with the aim of finding out how to improve the level of reading comprehension of secondary school students in this particular research. In May 2023, we went to the high school to administer the reading comprehension test to the students (prior approvals) and collect the rest of the data. In June 2023, we began quantitative analysis of the data to determine the extent to which a particular digital modality of information input improves reading comprehension.

Participants

Sampling was intentional and by accessibility, selecting seventh graders from a high school in a Spanish educational center with an intermediate socioeconomic level.

The sample consisted of 132 seventh graders (49% male and 51% female) aged 12 to 13 years (M=12.55; SD =0.49). The entire sample attended seventh grade and their first language was Spanish. The criteria to be included in the sample were: seventh grade attendance at the educational center, signed parental consent to participate in the study, attendance in class on the day of the reading comprehension test, and no diagnosis of a neurodevelopmental disorder. All students received the three modalities digitally and were adequately informed (both the students and their parents) about the purpose of the study, following the criteria indicated in the Declaration of Helsinki.

Instruments

To assess the level of reading comprehension, a validated and standardized objective test in Spanish was used, such as the Reading Comprehension Battery for the Evaluation of Reading Processes in Secondary and High School (PROLEC-SE -R) (Cuetos et al., 2016). This task consisted of two expository texts with ten open-ended questions after each text. In this study, only one expository text and its ten open-ended questions were used. These ten questions were divided into five questions measuring literal reading comprehension and five questions measuring inferential reading comprehension. The score for each question ranged from 0 to 1 point, so the range of scores for an expository text read ranged from 0 to 10 points. A score of 0 or 1 point was given to determine whether the answer was correct or incorrect, according to the answers specified as correct in the test manual. Thus, an overall reading comprehension score of 0-10 points, a literal reading comprehension score of 0-5 points, and an

inferential reading comprehension score of 0-5 points could be determined.

Each student read the text in the appropriate digital modality individually and silently and answered the ten responses via a Google form. The approximate duration of the test was fifteen minutes. The reliability of the reading comprehension test for this sample was calculated using Cronbach's alpha (α=0.877), suggesting high reliability.

Academic performance was collected from the educational center secretary of each participating student. This academic grade is the average of the grades in all subjects that the students had in the seventh grade. This grade ranged from 0 to 10 points, where 0-4.99 is a failing grade, 5-6.99 is a passing grade, 7-8.99 is an outstanding grade, and 9-10 is an excellent grade. These academic achievement data were collected to verify whether or not the three groups that made up the three digital modalities were balanced and whether or not they were able to influence the reading comprehension results. Sociodemographic data on age and gender were collected using Google forms.

Procedure

First, as part of the research visit, all necessary permissions and consents for data collection were obtained from the educational center and the students' parents, both in person at the educational center and online from the parents. In addition, an appointment and time were made to visit the school to administer the reading comprehension test in person, accompanied by a teacher from the school.

Second, the reading comprehension test in printed format was adapted to digital format. In visual modality 1, the text was written on a PowerPoint slide and converted into a presentation with a time interval of twenty-five seconds. In auditory modality 2, the text was recorded with the PowerPoint recorder in a neutral female voice at a time

interval of 25 seconds. In modality 3 dual, the slide and the recording made in modality 1 and 2 were merged in PowerPoint.

Third, the reading comprehension test was administered, and socio-demographic data were collected confidentially and anonymously. All students were brought to a classroom in the educational center, each with a digital tablet and headphones.

Each student had to take a slip of paper individually, and each slip of paper had the number one, two, or three on it, with forty-four slips of paper with the number one, forty-four slips of paper with the number two, and forty-four slips of paper with the number three. Subsequently, all students received two links in an email, one link that led to the reading comprehension test according to their assigned modality (papers numbered two and three required the use of headphones), and one link to a Google form in which the questions they had to answer from the text they had read, and the sociodemographic data were adapted. Adaptation of the questions consisted of copying them verbatim from the test into the Google forms as short-answer questions.

All students took the reading comprehension test at the same time so that answers could not be shared between students and the reading comprehension test was administered under the same conditions. All students submitted the Google forms.

Data analysis

Data analysis was conducted in several phases. On the one hand, we made a descriptive analysis to determine the normality of the variables using the Kolmogorov-Smirnov test and found a significance of less than 0.05, indicating non-normality and therefore requiring the use of non-parametric tests. On the other hand, descriptive statistics such as mean and standard deviation for global reading comprehension, literal reading comprehension, and inferential reading comprehension, as well as inferential analysis, using the Kruskal-Wallis H test, were performed to compare the results of the three

modalities. Then, multiple comparisons were performed to see in which modalities there were significant differences using the nonparametric Mann-Whitney U test. On the other hand, an inferential analysis was performed with the Wilcoxon Signed Rank Test (W) to investigate the presence of differences between literal reading comprehension and inferential reading comprehension in each type of digital modality. To calculate the effect size and its interpretation (López-Martín & Ardura-Martínez, 2023), the epsilon square (ε^2) was used for the inferential analysis with the Kruskal-Wallis H test and the biserial rank correlation for the inferential analysis with Mann-Whitney U and Wilcoxon Signed Rank tests (W).

Age, gender, and academic performance (school grade) are variables that may influence and compromise the results. For this reason, we analyzed differences by gender, age, and academic performance among the three digital modalities of information presentation. For gender (male-female) and age (12-13 years), the non-parametric Mann-Whitney U test was used, and for academic achievement (range 5-10 points), the Kruskal-Wallis H test was employed.

Analyses of the research data were conducted using SPSS version 27 (IBM, 2016) and for effect size using R (R Core Team, 2021). The significance level was equal to 0.05 for all analyses.

Results

First, the results of the previous analysis controlling for differences in age, gender, and academic performance (school grade) are presented. Next, the results of the inferential analysis of reading comprehension between the three modalities (visual, auditory, and dual) are depicted.

Preliminary analysis

The design used assumes randomization of the sample, but we wanted to verify that factors such as age, gender, and academic performance (school grade) did not affect the results and that the three configured groups had similar characteristics.

The previous analysis by age (12-13 years) using the Mann-Whitney U test showed that there were no significant differences between the three modalities (n=132, U=1883.500, p=0.211). Analysis by gender (male/female) using the Mann-Whitney U test revealed that there were no significant differences between the three modalities (n=132, U=1983.500, p=0.371). Analysis by academic performance (school grade) with Kruskal-Wallis H showed that there were no significant differences between the three modalities (n=132, H=6804, p=0.236). These results, broken down by age, gender and academic performance, show that the three groups (modalities) performed similarly in reading comprehension and were not a source of relevant differences that could compromise the results of the study.

Inferential Analysis

Descriptive analysis using mean and standard deviation shows, at a general level, a low level of students in global reading comprehension (M=6.09; SD =0.16) with a range from 0 to 10 points, a good level in literal reading comprehension (M=4.19; SD =0.06) with a range from 0 to 5 points, and a very low level in inferential reading comprehension (M=1.98; SD =0.11) with a range from 0 to 5 points. Table 1 shows the existence of significant differences between digital modalities in global reading comprehension (H=24.159, p=0.000, effect size=0.184), literal reading comprehension (H=9.487, p=0.009, effect size=0.072), and inferential reading comprehension (H=20.160, p=0.000, effect size=0.155). The effect size was large in global and literal

reading comprehension and moderate in literal reading comprehension.

Table 1. Results on inferential reading comprehension by digital modality.

Specifically, pairwise comparisons were made to analyze between which modalities the significant differences occurred in global reading comprehension, literal reading comprehension, and inferential reading comprehension. Table 2 shows the pairwise inferential results for global reading comprehension, literal reading comprehension, and inferential reading comprehension, as well as the biserial rank correlation for effect size. The effect size was large for the significant difference between auditory and dual modality in global reading comprehension and inferential reading comprehension. For all other significant comparisons, the effect size was moderate.

Table 2. Pairwise comparisons.

For the inferential analysis between the level of literal reading comprehension and inferential reading comprehension in each type of digital modality (visual, auditory, and dual), we used the nonparametric Wilcoxon Signed Rank Test (W) and biserial rank correlation for effect size. Table 3 shows that seventh graders performed significantly better in literal reading comprehension than in inferential reading comprehension at the general level (W=9891, p=0.000, effect size=-1.00), visual modality (W=5781, p=0.000, effect size=1), auditory modality (W=5376, p=0.000, effect size=1), and dual modality (W=5762, p=0.000, effect size=1). The effect size was large in global, visual, auditory and dual modalities reading comprehension.

Table 3. Results on inferential and literal reading comprehension.

Discussion

This research proves that the dual modality of information input improves the level of

digital reading comprehension of secondary school students the most. This result reflects the effectiveness of dual modality compared to visual and auditory modalities in digital reading comprehension in the first language, as shown in Table 1 and Table 2 with the non-parametric Kruskal-Wallis H-test and Mann-Whitney U-test, respectively.

The results of the study show that the null hypothesis is rejected, and the alternative hypothesis is accepted, i.e., there are differences in digital reading comprehension between the modalities of information input in favor of the dual modality. The dual modality improves digital reading comprehension significantly more than the visual and auditory modalities, both at the general, literal, and inferential levels. This finding is in line with other studies (Barahani & Ghafournia, 2015; Kuo et al., 2010; Vera, 2015) that have found a greater effect of dual modality compared to monomodality on reading comprehension and greater enrichment of multimodal presentation (Guo et al., 2020; Mayer, 2009). This finding confirms CTML (Mayer, 2009) in that secondary school students performed better on digital reading comprehension tasks when dual-modality information was presented.

Learners benefit from the integration of visual and auditory information and construct a mental representation of the text with greater meaning compared to the auditory or visual modality (Mayer, 2014). This gain in dual modality occurred at both the literal and inferential reading comprehension levels, reflecting a deeper understanding of the information, following CTML (Mayer, 2009). In this direction, there are studies that indicate that multimodality significantly increases the reading comprehension of students with low reading skills (Meneses et al., 2018) and benefits students with low academic achievement (Álvarez-Alonso et al., 2021). However, there are no differences between the visual and auditory modality, whose performances in the digital reading comprehension task were similar, slightly lower in the auditory modality.

We could hypothesize that the auditory modality requires greater abstraction of information than the visual modality, so that performance in the reading comprehension tasks is lower in both literal and inferential reading comprehension.

On the other hand, the results obtained confirm the second alternative hypothesis (H2), that is, there were significant differences between the literal and inferential levels of reading comprehension in the three digital modalities and at the general level, as shown in Table 3 with the nonparametric Wilcoxon Signed Rank (W) test. There are no studies that allow us to compare our results, but reviewing the scientific literature (De-la-Peña & Luque-Rojas, 2021; Del Pino-Yépez et al., 2019; Márquez et al., 2016), we found better performance on literal-level tasks compared to inferential-level tasks in agreement with this research. Secondary school students performed significantly better on literal reading comprehension tasks than on inferential reading comprehension tasks in all modalities, with better results in the dual and visual domains and slightly worse results in the auditory domain. It can be concluded that regardless of multimodality or monomodality, students are more successful on tasks that involve superficial presentation of information (Kintsch, 1998). Therefore, it is necessary to work in the classroom with digital expository texts to develop strategies that promote the creation of a deep mental representation that integrates explicit and implicit data, experiences, and prior knowledge (van den Broek et al., 2016) building a situation model (Kintsch, 1998).

This study provides a meaningful learning context for secondary students as it allows for the development of digital reading comprehension, which is one of the linguistic competencies needed academically and personally. Recent studies (Hahnel, 2017) address the development of different skills for digital reading comprehension as a competency that needs to be consolidated in a digitized environment with multimodal

information input. In this sense, secondary school instruction must be characterized by the interactivity of digital resources (Chen & Tang, 2023) to promote the development of skills such as reading comprehension. The data from this study demonstrate the effectiveness of the dual digital modality in reading comprehension. Educational professionals can design and apply various innovative reading comprehension interventions, literal, and inferential tasks in the classroom using digital resources that combine visual and auditory information. Nowadays, digital reading comprehension is not accompanied by formative development, as is the case with print reading comprehension (Moreira et al., 2020).

This study provides objective data showing the usefulness of dual modality in reading comprehension tasks and the low level in inferential reading comprehension tasks. This finding motivates us to continue working in this direction in formal and informal courses for secondary school students. In this study, free resources were used to create the presentation modalities of reading comprehension tasks and inferential reading comprehension tasks.

Limitations and Outlook

This study has limitations that may affect the results obtained. The sample size could be even larger and could be from other secondary school grades. Only one grade was selected to avoid the influence of the maturation effect of older grades and the resulting proficiency level, since it can be assumed that older students have better language skills, including reading comprehension. Second, controlling for intervening variables in the study. In this case, we tried to mitigate this situation by conducting a prior analysis to ensure that at least age, gender, and academic performance (final academic grade of the course) did not affect the results and that the three randomly formed groups had similar characteristics.

In addition, other text types could be used, such as narrative texts, and the benefits of dual modality versus visual and auditory modality in reading comprehension and the improvement of literal level versus inferential level of reading comprehension could be tested. Finally, we propose to repeat the study in other opaque languages such as English or in a second language to investigate whether the dual modality results are maintained.

Conclusions

This study focuses on demonstrating that the dual digital modality of information input improves secondary students' reading comprehension more than the visual digital modality and auditory digital modality. Furthermore, this study shows that the literal level performs significantly better than the inferential level of reading comprehension across the three digital modalities. For this purpose, a validated and graded reading comprehension task with an expository text for secondary school students with Spanish as their first language was used.

The current educational context, with the goals of 2030 Agenda that emphasize quality education, the results of international assessments that emphasize the improvement of reading comprehension, and the pervasiveness of digitalization provide the framework for this research. In particular, the study of the multimodality of information input in reading comprehension is now more relevant than ever to optimize students' educational competencies.

The pedagogical implications of this work imply improving the educational process for secondary school students. On the one hand, the development of teaching interventions that use a dual modality of information presentation by introducing digital methodological innovations. An example of this would be the use of a digital screen that records everything the teacher says in the classroom. In this sense, Nguyen et al. (2020)

pointed out that language comprehension is improved by using technology to instantly transcribe the spoken text. On the other hand, optimizing the inference level of digital reading comprehension is promoted through active learning methodologies with digital resources in the classroom. For example, in English as a second language, Hall et al. (2020) implemented a program of inference training for students with reading comprehension difficulties and achieved significant improvements in these students' final reading comprehension performance. Without doubt, being literate in today's world involves the acquisition of a wide variety of skills and practices with different digital inputs (i.e., mobile phones, games consoles, computers, etc.) that demand students interpret and negotiate a wide repertoire of representational modes in meaningful contexts (Flewitt, 2008).

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Declaration of interest statement

The authors report there are no competing interests to declare.

Data availability statement

The data that support the findings of this study are available from the corresponding author.

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Table 1. Results on inferential reading comprehension by digital modality.

Variable	Modality	N	Average Rank	H	p	Effect size (ε^2)
Global reading comprehension	Visual	44	58.83	24.159	0.000*	0.184
	Auditory	44	51.70			
	Dual	44	88.97			
Literal reading comprehension	Visual	44	59.30	9.487	0.009*	0.072
	Auditory	44	60.25			
	Dual	44	79.95			
Inferential reading comprehension	Visual	44	58.44	20.160	0.000*	0.155
	Auditory	44	53.52			
	Dual	44	86.50			

*$p < 0.05$

Table 2. Pairwise comparisons.

Comparisons	Modality	U	p	Effect size (r_b)
Global reading comprehension	Visual-Auditory	909.000	0.616	0.06
	Visual-Dual	571.500	0.001*	0.410
	Auditory-Dual	376.000	0.000*	0.612
Literal reading comprehension	Visual-Auditory	941.000	0.811	0.803
	Visual-Dual	678.000	0.009*	0.300
	Auditory-Dual	666.000	0.006*	0.312
Inferential reading comprehension	Visual-Auditory	925.500	0.711	0.04
	Visual-Dual	571.000	0.001*	0.396
	Auditory-Dual	439.500	0.000*	0.535

*$p < 0.05$

Table 3. Results on inferential and literal reading comprehension.

Reading comprehension		Average Rank	Rank Sum	W	p	Effect size (r_b)
Global	Negative ranks	64	8128.00	9891	0.000*	1
	Positive ranks	0	0			
	Ties	4				
Visual	Negative ranks	22.00	946.00	5781	0.000*	1
	Positive ranks	0	0			
	Ties	1				
Auditory	Negative ranks	18.50	666.00	5376	0.000*	1
	Positive ranks	0	0			
	Ties	8				
Dual	Negative ranks	22.00	946.00	5762	0.000*	1
	Positive ranks	0	0			
	Ties					

*$p < 0.05$