

# Enhancing reading comprehension through digital mind mapping: A quasi-experimental study with fourth-grade primary students

Esat Dođru <sup>1</sup>, Süleyman Erkam Sulak <sup>2</sup>

<sup>1</sup> Ordu University, Institute of Social Science, Ordu, Türkiye; <sup>2</sup> Ordu University, Faculty of Education, Ordu, Türkiye

## ABSTRACT

Reading comprehension is a complex cognitive process that involves analyzing, making sense of, and interpreting a text. Developing this skill from the primary school level is essential for both academic success and lifelong learning. In literature, the effects of various instructional strategies on reading comprehension have been extensively examined. In this context, digital mind maps have emerged in recent years as one of the most prominent innovative techniques. The purpose of this study is to investigate the effect of digital mind maps on the reading comprehension skills of 4th-grade primary school students. The study was conducted with 28 students attending a public school in the province of Ordu during the 2022–2023 academic year. The experimental group consisted of 15 students, while the control group included 13 students. A quasi-experimental design with a pre-test–post-test control group model was employed. Two different types of reading comprehension tests were used as data collection tools. The findings revealed that digital mind maps had a significantly positive effect on students' development of reading comprehension abilities. The results provide strong evidence that digital mind maps can be effectively utilized to enhance instructional efficiency across various subject areas.

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Süleyman Erkam Sulak



## Introduction

Reading is a complex cognitive process that serves as a foundation for individuals to construct meaningful relationships. This process involves not only decoding written symbols but also encompasses higher-order mental operations such as understanding, interpreting, critiquing the content of the text, and relating it to prior knowledge. Reading comprehension is a fundamental skill that needs to be developed from an early age in order for individuals to function effectively in both academic and social contexts (Snow, 2002; Güneş, 2021). In this context, supporting the reading comprehension processes of primary school students is of critical importance for enhancing their thinking skills, strengthening their problem-solving abilities, and diversifying their ways of accessing information.

The comprehension process involves transforming the information presented in a text into meaningful mental structures in the reader's mind. This transformation occurs through the integration of prior knowledge, inferences, and conceptual coherence. Therefore, an effective comprehension process requires not just mechanical reading, but the systematic use of pre-reading preparation, monitoring during reading, and post-reading evaluation strategies (Duke & Pearson, 2002). Implementing instructional models based on these strategies, especially for young learners receiving early reading education, lays the groundwork for permanent and meaningful learning.

Contemporary instructional approaches emphasize active participation of the learner in the learning process. Reading strategies developed in line with these approaches aim for students to understand texts

not only at a surface level but also in depth. One such strategy is the mind mapping technique, which serves as an effective learning tool by allowing information to be organized visually and conceptual connections to be concretized (Buzan, 2020). Mind maps are visual representations structured around a central concept using keywords, symbols, colors, and short phrases, encouraging both holistic and detailed thinking. In this way, they offer significant contributions to students' ability to structure information, engage in relational thinking, and transfer learned material to long-term memory (van Merriënboer & Sweller, 2010).

The positive impact of mind maps on learning has taken on a new dimension with the integration of technology into educational processes. Traditionally created on paper, these maps become more interactive and customizable when transferred to digital platforms, thanks to the affordances of multimedia. Digital mind mapping offers an instructional strategy in which learning materials are integrated with visuals, colors, symbols, links, and text, enabling students to engage more actively with the content (Bhattacharya & Mohalik, 2020).

Through the use of digital mind mapping strategies, students can process information more rapidly and perceive conceptual relationships more clearly. Digital mind mapping was a creative and flexible practice rather than a rigid method; it can be shaped in ways unique to each user. This strategy accommodates personal interests, learning needs, and the nature of the content, and thus, there is no single correct way to apply it (Bhattacharya & Mohalik, 2020). Therefore, following a systematic process is recommended to create an effective digital mind map. The suggested steps for the digital mapping process are as follows:

1. Begin with a blank screen.
2. Visualize the main idea or theme as a central node.
3. Generate sub-ideas or related concepts through brainstorming, branching out from the central idea.
4. Show relationships among concepts using connecting lines; diagram elements can be dragged and reorganized as needed.
5. Enhance the map with visual elements such as colors, shapes, and icons to support cognitive organization and create a personalized learning experience (Bhattacharya & Mohalik, 2020).

These steps not only facilitate the establishment of connections between concepts but also encourage students to participate actively in the learning process. Considering the concrete learning needs of primary-level students, it becomes evident that such visual and interactive structures make learning more effective.

Given the cognitive development levels of primary school students, concretizing learning and supporting it with visual tools are of great significance. Digital mind maps reduce cognitive load and make information more meaningful, while also positively influencing students' attitudes toward learning (Alomari & Al Horani, 2019). The use of color, shape, visual elements, and interactive features helps sustain attention and promotes active participation in learning processes. Furthermore, this technique functions as a pedagogical tool that supports learners in managing their own learning, developing self-regulation strategies, and restructuring knowledge (Sun et al., 2021).

Recent studies have directly demonstrated the effects of digital mind maps on students' reading comprehension skills. In a study conducted by Mohaidat (2018), it was found that students who used electronic mind maps were able to grasp texts more holistically and establish stronger connections between main ideas and supporting details. Similarly, Hardiyanti et al. (2021) emphasized that digital mind maps enhance attention, analytical thinking, and the ability to establish connections between concepts in reading comprehension processes. These findings indicate that digital mind maps should not be viewed merely as learning tools but also as cognitive support systems that deepen students' meaning-making processes.

The integration of digital mind maps into learning environments enables teachers to present instructional content in a more structured and visualized manner, while allowing students to make sense of complex concepts more easily. Especially in Turkish language lessons, the use of this strategy in teaching reading comprehension provides significant advantages in terms of analyzing the internal structure of texts and mentally mapping the content. Additionally, digital maps have been shown to diversify students' approaches to information and assist in analyzing the differences in meaning construction across various text types (Yan & Kim, 2023).

Accordingly, digital mind maps stand out not only as tools for individual learning but also as instruments suitable for collaborative learning environments. Thanks to their shareability, students can actively participate in the processes of co-constructing ideas, giving mutual feedback, and producing knowledge based on the mind maps they create. This transforms the learning process into one based not only on knowledge acquisition, but also on meaning-making, association, and critical evaluation.

In light of all these considerations, it is understood that digital mind maps provide multifaceted contributions to students' processes of constructing meaning, connecting concepts, and organizing

information within the context of reading instruction. The integration of this contribution into learning processes—particularly at the level of primary education—constitutes a significant example of how digitalization in education can attain pedagogical depth. This study aims to evaluate the effect of digital mind maps on the reading comprehension skills of fourth-grade primary school students and to demonstrate the pedagogical effectiveness of this strategy. In line with this main objective, the following sub-objectives of the study have been determined:

1. Is there a significant difference between the pre-test, post-test, and retention scores of the experimental group, which received instruction using the digital mind mapping strategy, and the control group, which received instruction based on the Turkish Language Curriculum, in narrative texts?
2. Is there a significant difference between the pre-test, post-test, and retention scores of the experimental group, which received instruction using the digital mind mapping strategy, and the control group, which received instruction based on the Turkish Language Curriculum, in informative texts?

## Method

### Research design

This study employed a quasi-experimental pretest-posttest control group design to examine the effect of digital mind maps on the reading comprehension skills of fourth-grade primary school students. Quasi-experimental designs are characterized by the investigation of the effects of an independent variable on experimental and control groups without random assignment of participants to these groups (Creswell, 2017). This design is especially preferred in educational research conducted in natural classroom environments where participants are already grouped (Karasar, 2012).

Researchers may select participants through random selection or random sampling methods, in which every individual in the population has an equal chance of being selected, ensuring that the sample represents the population. However, in many experimental studies, due to the use of pre-existing groups or volunteers, only convenience sampling can be employed. When individuals are not randomly assigned, the study is considered quasi-experimental (Creswell, 2017). In experimental studies conducted in public schools, it is typically not feasible to reassign students to different classes; thus, random assignment to experimental and control groups is often not possible.

### Study group

The study group consisted of a total of 28 fourth-grade students attending a public primary school in the province of Ordu during the 2022–2023 academic year. Of these students, 15 were assigned to the experimental group and 13 to the control group. The participants were selected using a convenience sampling method (Yıldırım & Şimşek, 2021). The groups were formed from classes with similar demographic characteristics, and attention was paid to ensure that the academic achievement levels of both groups were comparable.

### Implementation process

The study was conducted with volunteer participants outside regular classroom hours. After the experimental and control groups were determined and pretests were administered, an instructional process lasting eight weeks began.

In order to ensure equal opportunity, students were selected from two similar fourth-grade classes with close academic profiles. All sessions were held in the school's computer lab, a familiar and quiet setting conducive to focused learning. The environment was arranged to promote both individual and collaborative activities. The researcher, who is also a certified classroom teacher, acted as the instructor during all sessions, ensuring consistency across the implementation.

During this period, selected narrative and informative texts were presented to students in both groups. These texts were aligned with the Turkish Language Curriculum objectives, covering themes such as friendship, responsibility, nature, and emotions. Texts were chosen from officially recommended textbooks and storybooks, and were pre-approved by subject experts for grade-level appropriateness.

In the experimental group, instruction was carried out through digital mind mapping. Students received a 2-hour introductory training session on how to use digital mind mapping tools (specifically MindMeister and Canva). This training included demonstrations on creating a central idea, branching out with keywords, adding relevant images or icons, and using color coding for categories. During weekly sessions, students

were asked to read a selected text, identify its main idea, extract supporting details, and build a digital mind map using school-provided tablets or PCs. They were encouraged to work in pairs to discuss the content and provide peer feedback, which enhanced collaborative engagement and cognitive reflection.

In the control group, the same texts were taught using traditional methods aligned with the Turkish Language Curriculum. Instruction followed the stages outlined in the teacher's guidebook. Students read the texts under teacher guidance and engaged in vocabulary exercises, question-answer activities, and summarization tasks. While the control group also had teacher support, the interaction among peers was more limited, and the materials used were solely text-based without the support of visuals or digital tools. Both groups received equivalent instructional time (2 hours per week) and similar difficulty-level tasks in order to maintain procedural validity. At the end of the process, the same tests were administered to both groups as posttests.

### Data analysis

The quantitative data collected in the study were analyzed using the SPSS 25.0 statistical software. To determine whether the test scores could be statistically compared, the normality of the data distribution was first assessed. The Shapiro-Wilk test results indicated that the pretest and posttest scores of both the experimental and control groups were normally distributed ( $p > .05$ ), allowing for the use of parametric tests.

To test the study hypotheses, comparisons were made between the pretest, posttest, and retention scores of the experimental and control groups. Independent samples t-tests were used to determine whether there were statistically significant differences between the means of the two groups. This test is appropriate for measuring the effect of a categorical independent variable (group type: experimental/control) on a continuous dependent variable (Büyükoztürk et al., 2020).

Throughout the data collection process, principles of validity and reliability were strictly observed. The administration of both the pretest and posttest by the same researcher to both groups helped eliminate variability due to different test administrators and contributed to the internal validity of the study. Furthermore, all test applications were carried out simultaneously, and equal time was allocated to all students to ensure standard testing conditions.

Scoring was conducted based on a predetermined answer key. To enhance objectivity, a classroom teacher also scored the tests, and results were compared for consistency. This procedure supported the reliability of the scoring process.

Regarding content validity, the appropriateness of the texts for the grade level and their effectiveness in measuring the targeted skills were evaluated by subject matter experts (Erkuş, 2006). Necessary revisions were made to the texts and test items in line with expert feedback.

In conclusion, the study adhered to statistical and methodological principles to ensure the valid and reliable collection, analysis, and interpretation of data. These analyses not only strengthened the scientific rigor of the study but also contributed to grounding the findings on a more solid educational foundation.

## Results

This section presents the findings obtained from the analysis of data collected from the experimental and control groups. The results are organized according to the sub-objectives of the study and are presented based on pre-test, post-test, and retention scores.

### Findings and interpretation of the normality test

To determine whether the data collected through the assessment tools were normally distributed, the Shapiro-Wilk test was conducted. According to the results, both pre-test and post-test scores for the experimental and control groups showed a normal distribution ( $p > .05$ ). This confirms the appropriateness of using parametric tests for further analysis.

### Reading comprehension scores for narrative texts

#### Pre-test results

The findings regarding the pre-test results for narrative texts are presented in Table 1:

Table 1. Independent samples t-test results for narrative text pre-test scores

Group	n	Mean (M)	Std. Dev. (SD)	df	t	p
Experimental	15	8.06	2.08	25	0.202	.842

Control	12	7.91	1.67
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\* $p > 0.05$

The analysis revealed no statistically significant difference between the two groups in pre-test scores ( $p > .05$ ), indicating that both groups had comparable reading comprehension levels before the intervention.

### Post-test results

The findings regarding the post-test results for narrative texts are presented in Table 2:

Table 2. Independent samples t-test results for narrative text post-test scores

Group	n	Mean (M)	Std. Dev. (SD)	df	t	p
Experimental	15	10.60	3.68	21.303	2.166	.042
Control	12	8.25	1.81			

\* $p < 0.05$

The results indicate a statistically significant difference between the experimental and control groups in the post-test scores [ $t_{(21.303)} = 2.166, p < .05$ ]. The experimental group's mean score ( $M = 10.60$ ) was higher than that of the control group ( $M = 8.25$ ). This suggests that the digital mind mapping strategy significantly improved students' comprehension of narrative texts.

### Retention test results

The findings regarding the retention scores for narrative texts are presented in Table 3:

Table 3. Independent samples t-test results for narrative text retention scores

Group	n	Mean (M)	Std. Dev. (SD)	df	t	p
Experimental	15	2.533	2.35	16.60	3.45	.003
Control	12	0.333	0.651			

$p < 0.05$

The independent samples t-test results revealed a significant difference in retention scores between the two groups [ $t_{(16.60)} = 3.45, p < .05$ ]. The experimental group's higher mean score demonstrates that digital mind mapping positively contributed to long-term comprehension gains.

## Reading comprehension scores for informative texts

### Pre-test results

The findings regarding the pre-test results for informative texts are presented in Table 4:

Table 4. Independent samples t-test results for informative text pre-test scores

Group	n	M	SD	df	t	p
Experimental	15	7.93	2.60	25	-1.794	.085
Control	12	9.66	2.34			

$p > 0.05$

No statistically significant difference was found in the pre-test scores for informative texts [ $t_{(25)} = -1.794, p > .05$ ], indicating similar baseline comprehension levels for both groups.

### Post-test results

The findings regarding the post-test results for informative texts are presented in Table 5:

Table 5. Independent samples t-test results for informative text reading comprehension post-test scores

Group	n	Mean (M)	Std. Dev. (SD)	df	t	p
Experimental	15	9.66	2.74	25	-0.170	.867
Control	12	9.83	2.24			

$p > 0.05$

The difference between post-test scores of the experimental and control groups was not statistically significant [ $t_{(25)} = -0.170, p > .05$ ]. This may indicate that the use of digital mind maps had a limited immediate effect on the comprehension of informative texts.

### Retention test scores

The results regarding the retention scores for informative texts are presented in Table 6:

Table 6. Independent samples t-test results for informative text reading comprehension retention scores

Group	n	M	SD	df	t	p
Experimental	15	1.733	1.38	19.55	3.96	.001
Control	12	0.166	0.577			

\* $p < 0.05$

The retention scores show a statistically significant difference in favor of the experimental group [ $t_{(19,55)} = 3.96, p < .05$ ]. This finding suggests that digital mind mapping was effective in supporting learning retention, even in informative texts.

## Conclusion, discussion, and recommendations

This study examined the effect of digital mind maps on the reading comprehension skills of fourth-grade primary school students. The research was structured around two text types—narrative and informative—and the data were analyzed through comparisons between experimental and control groups. The results demonstrated that digital mind maps had a significant effect on improving reading comprehension levels, particularly in narrative texts; in informative texts, they contributed notably to retention (learning gains).

The effectiveness of digital mind maps stems from their ability to help students process texts not only at a superficial level but also at semantic and structural levels. Students were able to grasp the coherence of a text within a visual and conceptual framework by positioning the main idea at the center and organizing supporting ideas around it. This structuring process promotes active cognitive processing during reading and facilitates meaning construction. Gagné, Wager, Golas, and Keller (2005) emphasize that learning is directly related to cognitive structures, and that constructing meaning occurs through the integration of information into mental schemas. In this context, mind maps emerge as functional tools in the development of these schematic structures.

The contribution of mind maps to learning is based on their capacity to enhance individuals' ability to organize information and establish meaningful connections. Novak and Cañas (2008) assert that concept maps and similar graphical learning tools support meaningful learning by helping learners connect new information with existing concepts. Similarly, Buzan (2020) argues that mind maps expand and deepen thinking through visualization and help develop students' conceptual frameworks by organizing knowledge hierarchically.

Studies conducted in Turkey also support these findings. For instance, Çamlı (2009) demonstrated that the computer-assisted mind mapping technique is an effective tool in enhancing student learning. Balım et al. (2006) found that courses taught using computer-assisted mind maps significantly increased student achievement compared to those taught with traditional methods. In the study by Debbag et al. (2021), digital mind maps were shown to contribute not only to reinforcement, assessment, and visualization in learning but also to increasing engagement and ease of use. These findings indicate that digital mind maps are not only cognitively beneficial but also pedagogically effective and functional tools.

The findings of the present study align with these views. The statistically significant improvement in both post-test and retention scores of the experimental group in narrative texts indicates that mind maps make a concrete contribution to the reading comprehension process. Digital mind maps, which help organize elements such as plot structure, character relationships, and cause-effect connections, supported students' understanding of the internal structure of the texts. This structuring process enabled students to employ metacognitive skills and engage with texts at a deeper level (Pressley & Afflerbach, 1995).

Although no significant difference was found in the post-test scores for informative texts, the significant increase in retention scores suggests that digital mind maps are functional in terms of restructuring and consolidating information during the learning process. In this regard, Sulak (2014) emphasizes that concept maps are more effective in the organization and retrieval of information rather than in initial knowledge acquisition. Similarly, Kim and Kim (2012) found that digital mind maps help individuals recall vocabulary more quickly and relate new terms to their prior knowledge.

Another reason for the positive effect of digital mind maps on reading comprehension is their support for multisensory interaction. According to Mayer's (2009) cognitive theory of multimedia learning, receiving information through both verbal and visual channels enhances meaning-making and improves retention. Digital mind maps, through the use of color, shapes, icons, and visual links, employ multiple representations to make learning more effective.

Erdem (2017) notes that mind maps help systematize students' thinking processes, accelerate access to information, and especially enhance the ability to make intertextual connections. This may explain the observed improvement in narrative text comprehension, as narrative texts—due to their structural coherence and chronological sequence—lend themselves more readily to conceptual mapping.

The strategy employed in this study enabled students not only to comprehend texts but also to mentally reconstruct meaning. Students started from the main idea, structured layers of supporting information,

established their own conceptual connections, and thus experienced learning more deeply. This process transformed the act of reading into an active and constructive experience, beyond the bounds of traditional instructional approaches (Duke & Pearson, 2002).

In conclusion, this study reveals that digital mind maps are an effective instructional strategy for improving reading comprehension skills. While their impact was more clearly observed in narrative texts, their contribution to learning gains in informative texts was also evident. Digital mind maps facilitated students' comprehension by enabling them to visualize and organize text content effectively. In this context, the integration of digital mind mapping into primary-level reading education can be regarded as an effective strategy that contributes to both individual learning processes and meaning-centered reading habits.

Based on the findings of this study, it is concluded that digital mind maps are particularly effective in enhancing reading comprehension skills. Accordingly, it is recommended that digital mind mapping strategies be systematically integrated into the instructional process of all text-based courses, especially the Turkish language curriculum. To ensure effective implementation, educators should be provided with in-service training and access to appropriate technological infrastructure. Moreover, to increase the impact of mind maps in informative texts, strategies such as prior knowledge activation, conceptual analysis, and structured guidance can be incorporated into the instructional process. Future research should investigate the effectiveness of digital mind maps across different age groups, text types, and interdisciplinary contexts in a more comprehensive manner.

## Declarations

### Competing interests

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