Mnemonic devices as tools for Information Design in an educational context

Recursos mnemônicos como ferramentas de Design da Informação em um contexto educacional

Dispositivos mnemotécnicos como herramientas de Diseño de la Información en un contexto educativo

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information design, design and education, cognitive ergonomics, information retention

This article presents findings from a dissertation focused on enhancing information retention in second language learning through mnemonic devices and information design. The study addresses the challenge of optimizing memory recall in educational settings. Its objective was to evaluate the impact of mnemonic-enhanced visual content on ESL learners. An experimental methodology was applied with 24 Portuguese-speaking participants (B2/C1 level), who *completed* two digital memory tests after viewing an edited music video. Results indicate a 25% improvement in retention and a 33.9% decrease in task completion time, suggesting potential for design-driven educational interventions.

design da informação, design e educação, ergonomia cognitiva, retenção de informação

Este artigo apresenta os resultados de uma dissertação focada na ampliação da retenção de informação no ensino de segunda língua por meio de dispositivos mnemônicos e design da informação. O estudo aborda o desafio de otimizar a memória em contextos educacionais. O objetivo foi avaliar o impacto de conteúdos visuais com reforço mnemônico em aprendizes de inglês. Utilizou-se metodologia experimental com 24 participantes lusófonos (níveis B2/C1), que realizaram dois testes digitais de memória após assistirem a um videoclipe editado. Os resultados indicam uma melhora de 25% na retenção e uma redução de 33,9% no tempo de resposta, sugerindo o potencial de intervenções educacionais orientadas pelo design.

diseño de la información, diseño y educación, ergonomía cognitiva, retención de información

Este artículo presenta los resultados de una disertación centrada en mejorar la retención de información en el aprendizaje de una segunda lengua mediante dispositivos mnemotécnicos y diseño de la información. El estudio aborda el desafío de optimizar la memoria en entornos educativos. El objetivo fue evaluar el impacto de contenido visual reforzado con elementos mnemónicos en estudiantes de inglés. Se utilizó una metodología experimental con 24 participantes lusohablantes (niveles B2/C1), quienes realizaron dos pruebas digitales de memoria tras ver un videoclip editado. Los resultados indican una mejora del 25% en la retención y una reducción del 33,9% en el tiempo de respuesta, lo que sugiere el potencial de intervenciones educativas basadas en el diseño.

1 Introduction

The increasing complexity of information in today's educational landscape necessitates innovative strategies to enhance learning and retention. Information design is a multidisciplinary field that focuses on structuring, organizing, and presenting information in ways that optimize comprehension, usability, and retention (Jacobson, 2000). Rooted in principles of cognitive psychology, graphic design, and human-computer interaction, it emphasizes clarity, hierarchy, and the strategic use of visual and textual elements to enhance learning experiences (Tufte, 2001; Wurman, 1996). Effective information design reduces cognitive load by guiding attention, minimizing extraneous processing, and fostering meaningful connections between concepts (Sweller, 1988; Mayer, 2005). In educational contexts, well-designed instructional materials can improve knowledge acquisition by aligning with learners' cognitive processes and leveraging affordances such as spatial organization, color coding, and visual metaphors (Norman, 2013).

By integrating mnemonic devices into information design, educators and designers can create more intuitive and memorable learning environments, reinforcing the encoding and retrieval of key information. In parallel, mnemonic devices have long been recognized as effective tools for improving recall and facilitating deeper cognitive processing (Lidwell; Holden; Butler, 2010). This paper explores the synergistic potential of combining advanced information design techniques with mnemonic strategies to boost information retention in educational settings.

Drawing on theoretical framework from the universal principle of design of depth of processing, the research posits that well-designed information—augmented with targeted mnemonic cues—can alleviate cognitive overload while promoting more efficient encoding and retrieval of complex material (Craik; Lockhart, 2008). Such integration not only aids memory but also fosters an engaging learning environment that can adapt to diverse educational needs.

This paper reports on the findings from a dissertation study, which evaluated the impact of these combined strategies across an educational context of English language learners all of whom were native Portuguese speakers. The dissertation's results, derived from an in-class experiment, demonstrate an improvement of 25% in learner performance. By bridging the domains of information design and mnemonic theory, the study offers evidence for the role of design-driven educational interventions in modern pedagogy.

2 Theoretical Framework

Perception and information processing are guided by communication, which occurs effectively when the receiver correctly interprets the message that the source intends to convey. Once communicated, the message triggers a sensation in the receiver, who captures environmental energy. Acting as an ally to sensation, often occurring simultaneously, perception gives meaning to the sensory stimulus by utilizing information stored in memory and converting it into knowledge. It is important to note that the same sensation can provoke different perceptions in each person and that perception occurs in two stages: pre-attention and attention. The pre-attention stage identifies color, shape, and movement, while the attention stage recognizes stimuli by using memory for comparisons (Iida, 2005).

According to Gazzaniga, Ivry, and Mangun (2019), memory refers to the persistence of acquired knowledge, which can later be brought into consciousness. Memory models operate at three levels of processing: sensory memory, short-term memory, and long-term memory, based on the duration for which information is retained. Sternberg (2016) states that sensory memory is the initial repository of the many pieces of information that will later be present in both short-term and long-term memory.

Perception, memory, and information processing play fundamental roles in how individuals interpret and retain information, directly influencing the effectiveness of information design. As a discipline that focuses on organizing and presenting information for optimal comprehension, information design relies on cognitive principles to enhance clarity, usability, and retention (Jacobson, 2000; Wurman, 1996). Given that perception occurs in stages—pre-attention and attention (Iida, 2005)—effective design must account for how users initially engage with visual and textual elements before deeper cognitive processing takes place. Features such as contrast, hierarchy, and spatial organization help guide attention and facilitate recognition, reducing cognitive load and improving accessibility (Sweller, 1988; Mayer, 2009).

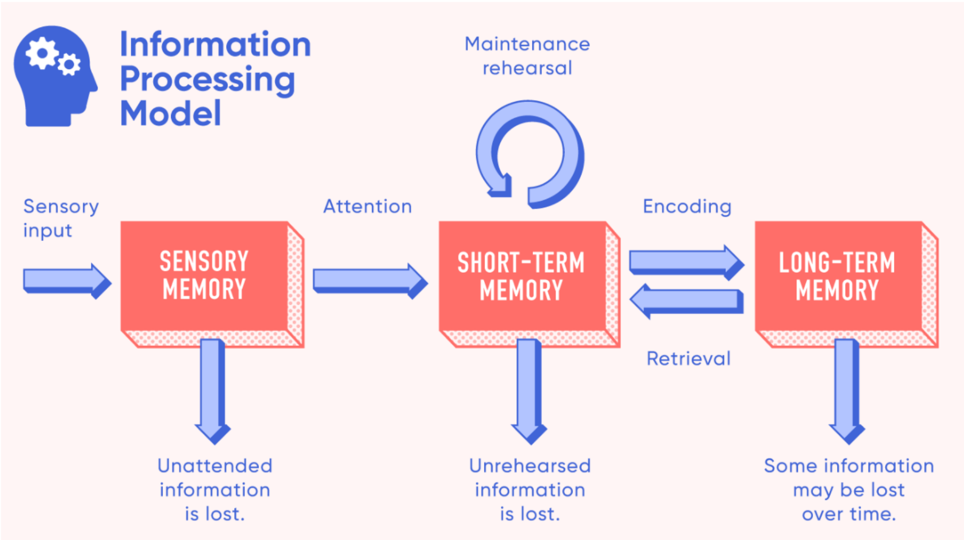
Moreover, memory structures influence how information is retained and recalled. Since sensory memory serves as the first repository of information before it is transferred to short- or long-term memory (Sternberg, 2016), well-designed materials must leverage strategies that align with this cognitive process. Mnemonic devices, for instance, enhance encoding by linking new information with existing knowledge (Gazzaniga, Ivry & Mangun, 2019), a principle that can be integrated into information design through structured layouts, meaningful associations, and multimodal elements. By considering how perception and memory interact with design, practitioners can create materials that not only communicate effectively but also foster deeper learning and retention.

In educational contexts, the integration of mnemonic resources into information design can significantly enhance learning by improving encoding, retention, and retrieval of information. Mnemonic devices operate by creating meaningful associations that strengthen memory traces, making information more accessible over time. When applied through strategic design choices, such as structured layouts, visual hierarchies, and multimodal content, these devices help reduce cognitive load and facilitate deeper processing (Sweller, 1988; Mayer, 2009).
In learning environments, visual mnemonics, such as diagrams, icons, and mind maps, leverage dual coding theory (Paivio, 1990) by combining verbal and visual information to enhance recall. Additionally, spatial organization and color-coding support chunking, an essential strategy for short-term memory retention. Interactive elements, such as gamified learning experiences and memory aids embedded in digital interfaces, further reinforce engagement and recall by tapping into active learning principles (Mayer, 2009; Norman, 2013).

By embedding mnemonic strategies into well-structured information design, educational materials become more effective, aiding students in constructing lasting mental models and improving knowledge retention.

Gazzaniga, Ivry, and Mangun (2019) outline five key stages of information processing (Figure 1) that play a crucial role in how individuals perceive, encode, store, and retrieve knowledge: sensation, perception, attention, memory, and executive function. These stages are deeply connected to how memory operates, influencing the effectiveness of learning strategies and, by extension, the design of educational materials.

Figure 1: Stages of information processing



Source: Gazzaniga, Ivry, Mangun (2019).

First, sensation involves the reception of stimuli from the environment, which is crucial for initial information intake. In learning environments, well-designed materials enhance sensory engagement by using visual contrast, auditory cues, and interactive elements to capture attention effectively. Second, perception assigns meaning to sensory input, integrating new information with existing cognitive schemas. Information design can facilitate this process by leveraging familiar patterns, structured hierarchies, and contextual cues to enhance comprehension (Norman, 2013).

The third stage, attention, determines which information is processed further, making it a critical factor in memory retention. Cognitive load theory (Sweller, 1988) suggests that reducing extraneous cognitive efforts such as through clear typographic hierarchy, chunking, and intuitive navigation—can improve learning outcomes. Fourth, memory enables the storage and retrieval of knowledge, where mnemonic strategies play a pivotal role. By linking new content to existing knowledge networks, mnemonics strengthen memory consolidation, a process that is reinforced during sleep (Gazzaniga, Ivry & Mangun, 2019).

Finally, executive functions govern higher-order cognitive processes, including problem-solving, decision-making, and learning regulation. Sleep is a fundamental component in optimizing executive function, as it plays a key role in memory consolidation, particularly in transferring information from short-term to long-term storage (Walker & Stickgold, 2006). During slow-wave and REM sleep, the brain strengthens neural connections, reinforcing the knowledge acquired during waking hours. Thus, educational materials designed with mnemonic strategies should not only consider cognitive load and perceptual design but also account for the natural cycles of memory consolidation, advocating for spaced learning and sleep-friendly study habits.

Integrating usability principles from Nielsen (1993) into the theoretical framework of this study strengthens the argument that well-structured information design enhances information retention and learning outcomes. Nielsen's heuristics—such as visibility of system status, consistency and standards, recognition rather than recall, and error prevention—are essential in ensuring that digital learning environments provide an intuitive and cognitively supportive experience for users.

In this study, the recognition rather than recall principle played a crucial role, as the Wordwall platform provided structured tasks that minimized the need for users to recall interface interactions, allowing them to focus on content retention. Additionally, consistency and standards contributed to learning effectiveness by ensuring that the mnemonic interventions followed predictable patterns, reinforcing encoding processes as described by Craik & Lockhart (2008).

Furthermore, error prevention was indirectly addressed by analyzing participants' mistakes in both memory tests. While the study revealed areas where the platform's interface design could improve, the general reduction in errors suggests that well-structured information, coupled with mnemonic aids, facilitates learning. Finally, visibility of system status is relevant in the context of digital learning tools, as clear feedback mechanisms help learners understand their progress and adjust their cognitive strategies accordingly.

By incorporating Nielsen's usability principles (1993) into the broader theoretical framework of information design, as depicted by Figure 2, this study highlights how effective interface design complements cognitive mechanisms such as semantic encoding and memory consolidation (Walker & Stickgold, 2006).

Figure 2: Nielsen's usability principles

Source: Nielsen (1993).

The alignment of usability with mnemonic strategies underscores the importance of designing digital educational experiences that optimize both information processing and user interaction, ultimately leading to better retention and learning outcomes.
The following section will present the methodological approach through which results from the experiment were obtained.

3 Materials and methods

Lakatos and Marconi (2008) state that qualitative research can be recognized by its depth of data analysis, as well as the differentiation in data collection methods and the limited use of statistical tools, when present. This type of research aims to understand the specific characteristics of the studied object by analyzing events within a given context. However, Demo (2012) asserts that qualitative phenomena possess quantitative characteristics and vice versa; therefore, this study will also present numerical indicators in its results. The research is exploratory with a qualitative approach, and the memory test is referred to as an experiment, consisting of two stages conducted at least 24 hours apart. This memory test was based on Experiment 9 from the study conducted by Craik; Lockhart (2008), which examined information retention of English verbs.

The proposed research investigates whether participants' exposure to the employed mnemonic resources positively influenced information retention and compares data collected from the first memory test with the second test to identify changes observed after participants had slept. Another relevant factor that characterizes this research is the mode of participation: students took part either in a remote or in-person format.

The target audience was defined as English as a second language (ESL) students at levels B2 and C1, according to the Common European Framework of Reference for Languages (CEFR). Participants included individuals of all genders, aged between 25 and 55 years, which were the inclusion criteria for the experiment. Apart from one participant, all had higher education degrees. The exclusion criteria were defined as follows: not meeting the proposed language proficiency level, being under the legal age, being over 55 years old, or not being an ESL student.

The software used to edit the music video was Microsoft Clipchamp, while Microsoft's media player was used to present the video to participants. The first memory test was conducted in the form of a crossword puzzle on the digital platform Wordwall. These tools were used for both in-person and remote participants.

Regarding the platform used: Wordwall was created in 2006 in London, England, within a classroom setting. This platform provided essential data regarding the memory tests conducted in this research, including task completion time, information correctly answered, information with the highest error and success rates, individualized reports for each participant detailing errors and correct answers and customization options for the task.

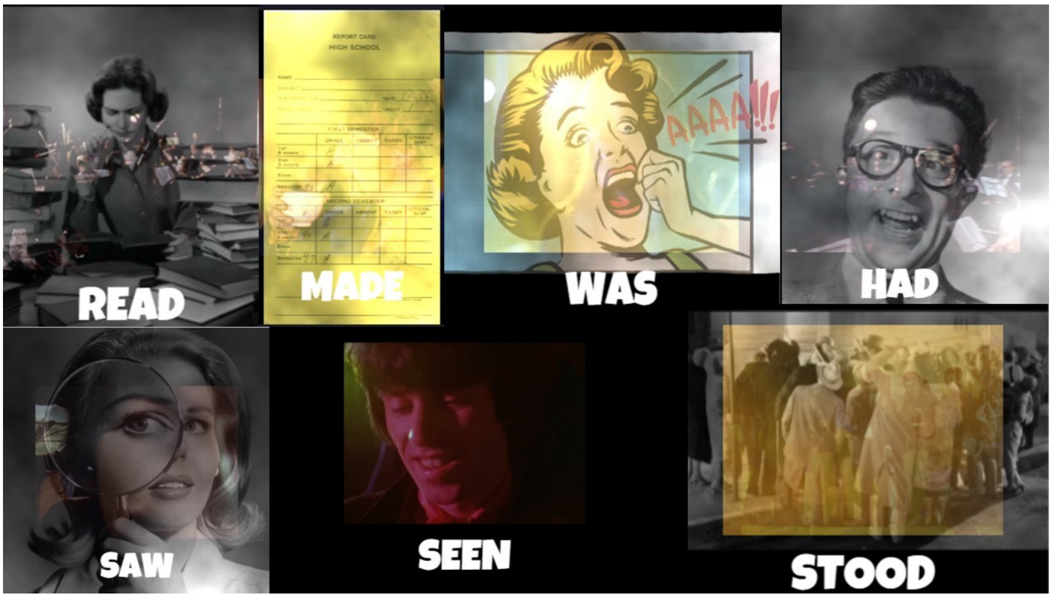
Initially, participants engaged in a warm-up activity, where the story behind the song *A Day in the Life* (from the British band *The Beatles*) was introduced. In this phase, participants were presented with a poster designed by Todd Alcott (Figure 4), which used lyrics from the song to simulate a newspaper headline on the day the person who inspired the composition, Tara Browne, died in a car accident. Next, participants were shown the original newspaper headline from December 19, 1966. The goal of this step was to immerse participants in the historical context in which the song was composed, while already referencing past events to promote semantic encoding proposed by Craik and Lockhart (2008).

Figure 3: Poster

Source: Todd Alcott (2016).

Following this, participants watched the modified version of the *A Day in the Life* music video, which lasted 5 minutes and 10 seconds. The content stressed in the video consisted of irregular verbs conjugated in the simple and past participle for of the English language, which is the information to be retrieved by the participants in both memory tests which follow, depicted in figures 5 and 6.

Figure 4: First seven verbs presented in music video



Source: author (2024).

In addition to the verbs above, figure 6 illustrates the others present in the video clip.

Figure 5: Last eight verbs presented in music video

Source: author (2024).

Remote participants used their own equipment (without specific hardware requirements), while in-person participants used a Dell Inspiron 3110 desktop computer and JBL Tour Pro headphones, provided by the researcher. The screen contrast was recommended to be set to the highest level. Participants were also advised to minimize any noise that could interfere with their listening and/or viewing of the music video.

The third and fourth stages consisted of two memory tests administered to the participants. The first memory test was conducted immediately after watching the video, while the second was administered at least 24 hours later. Both memory tests were identical and consisted of 15 multiple-choice questions. The goal of the second memory test was to assess the impact of sleep on participants' learning and information retention.

4 Results

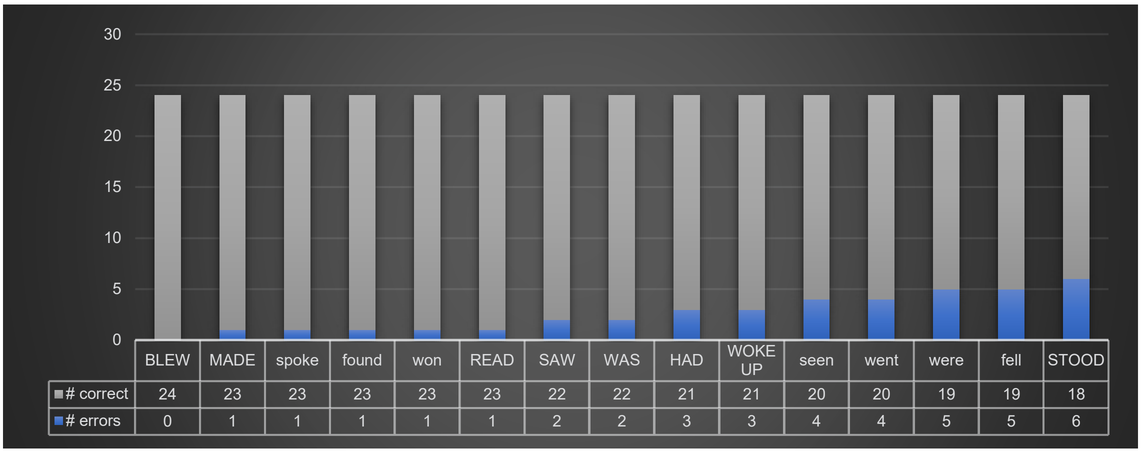
Graph 1 illustrates the total number of verbs (15) presented in the video clip which were tested for recall, as well as displaying the information in a stacked column format. Thus, the total number of responses per verb was 24 (equivalent to the number of participants in the experiment). Verbs that had an added image in the video clip are written in uppercase. In addition to *made* and *woke up*, the verbs *saw*, *was*, *had*, *blew*, *read*, and *stood* also underwent the same intervention. Given this, it is observed that the verbs subjected to this intervention account for 26 errors in total, representing 50% of the total errors recorded in Memory Test 1.

Graph 1: Results from Memory Test 1 (immediately after viewing video clip)

Source: author (2024).

Graph 2, also in a stacked column format, highlights the previously mentioned reduction in errors. A 25% decrease in the total number of errors was observed, dropping from 52 errors in Test 1 to 39. While in Test 1, the verbs with image intervention (marked in uppercase in the graph) accounted for 50% of the errors, in Memory Test 2, they represented 46.1% of the total errors.

Graph 2: Results from Memory Test 2 (done at least 24 hours after Memory Test 1)



Source: author (2024).

The reduction in response time in 91.68% of cases, when comparing both memory tests as shown in Table 1, is another noteworthy factor. The average response time in Test 1 was 3 minutes and 33 seconds, while in Test 2, it decreased to 2 minutes and 20 seconds, representing a 33.9% reduction.

Table 1: Comparison of time taken to complete Memory Tests 1 and 2

Participant #	Time elapsed MT1	Time elapsed MT2	Representation of total
1	00:02:37	00:01:49	4,16%
2	00:04:27	00:03:08	4,16%
3	00:03:28	00:02:39	4,16%
4	00:05:11	00:03:44	4,16%
5	00:02:36	00:02:20	4,16%
6	00:02:14	00:01:54	4,16%
7	00:04:09	00:02:55	4,16%
8	00:01:15	00:01:12	4,16%
9	00:03:35	00:01:39	4,16%
10	00:02:18	00:02:19	4,16%
11	00:02:24	00:03:04	4,16%
12	00:05:25	00:03:39	4,16%
13	00:02:35	00:02:29	4,16%
14	00:10:19	00:07:01	4,16%
15	00:03:53	00:02:27	4,16%
16	00:06:39	00:01:51	4,16%
17	00:03:51	00:02:33	4,16%
18	00:02:29	00:02:20	4,16%
19	00:03:31	00:02:31	4,16%

20	00:03:55	00:01:46	4,16%
21	00:02:54	00:01:41	4,16%
22	00:04:10	00:02:12	4,16%
23	00:04:01	00:01:34	4,16%
24	00:03:13	00:02:17	4,16%
Average time elapsed	**00:03:33**	**00:02:20**	
Total			**100%**

Only participants 10 and 11 showed an increase in response time. Participant 10 had an increase of just 1 second compared to Test 1, which is considered statistically insignificant. It can be stated that no participant forgot how to use the Wordwall platform, or the content presented in the music video.

Participants 8, 9, 10, 18, 19, 20, 21, 22, 23, and 24 were part of classroom groups. This factor may have influenced response time due to the competitive nature of completing a task simultaneously with classmates. Group performance tends to be more intense compared to an individual setting, which may have pressured classroom participants to answer the tests more quickly.

The combination of error reduction with decreased response time indicates an aspect related to usability. Based on the comparison of participants' response times, it is possible to verify that the Wordwall platform demonstrated good memorization levels, as the reduction in response time could be linked to increased ease of interface navigation. However, despite this attribute, the platform's efficiency of use was not universally perceived as a positive factor, especially considering feedback from research participants.

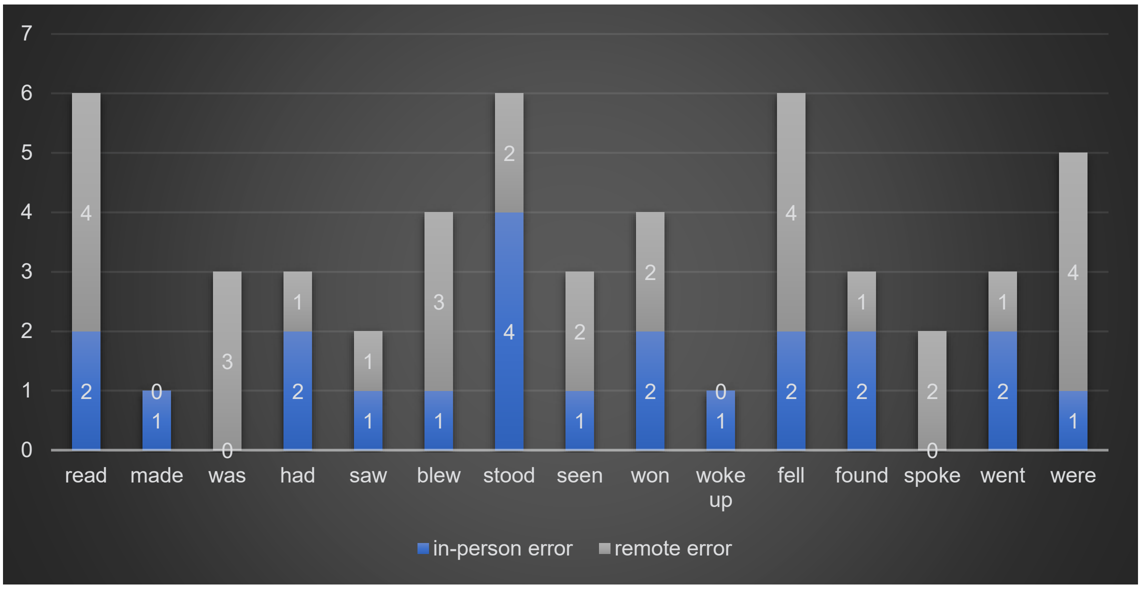
For example, participant 15 reported feeling "confused about the color of the letters once typed into the system." This participant initially believed that the different colors appearing as letters were typed indicated some form of system feedback—signaling correct or incorrect answers—though this was not the platform's intended functionality. Participant 16 expressed the same opinion.

Participant 11, who took the test in person, reported difficulties in completing the task because they were using the machine provided by the researcher rather than their own. This participant also mentioned that the system did not provide accurate feedback when answers were entered, and such opinions that were also shared by participants 15 and 16. Additionally, participant 11 had the longest interval between tests (83 days), which may explain the increase in time spent on Test 2. The other participants followed the standard interval of 7 days between tests.

Graph 3 compares the number of correct and incorrect answers between participants in the in-person format and those in the remote format. In Test 1, 22 errors were observed among in-person participants, while remote participants made 30 errors. It is important to highlight that in-person participants accounted for 20.8% of the sample, whereas remote participants made up

79.2% of the total. Here, it is possible to infer that the use of a personal device may play a key role in task performance, as in-person participants used the computer and headphones provided by the researcher, whereas remote participants used their own equipment.

Graph 3: In-person error vs. remote error comparison



Source: author (2024).

In Test 2, as indicated by graph 4, the number of errors among remote participants was 28 (a reduction of 2 errors), while in-person participants recorded a total of 11 errors (a reduction of 11 errors). The significant decrease in errors among in-person participants (especially considering their sample representation of 20.8%) suggests better performance in the in-person modality.

Graph 5 compares the number of errors between individual participants (private lessons) and group participants (classroom settings). As shown, individual participants made 35 errors in Test 1, whereas group participants made 17 errors. This data suggests that individual participants may have felt more pressure to achieve a positive outcome compared to group participants. During the experiment, individual participants were alone with the researcher, while group participants completed the experiment in a classroom setting along with peers. In this case, the collective environment may have alleviated psychological pressure, reducing the stress associated with providing a correct response.

5 Conclusion

Regarding human factors in design specifically, long-term information retention was observed—supporting Craik and Lockhart's (2008) assertions on semantic encoding and the meaningfulness of information. The instructional content proved to be relevant enough for participants to achieve better results a day or more after being exposed to the material, as indicated by the results. Thus, sleep can be considered a key factor in information processing and consolidation, confirming the claims made by Walker & Stickgold (2006).

An additional factor contributing to content retention was the participants' familiarity with the platform. The learning and memorization of the platform's interface may have positively influenced their results alongside content retention. This argument is supported by data related to the verb *read*, which was the first question in the memory test, the first to be answered by participants due to its numerical order. In Test 1, *read* accounted for six errors, whereas in Test 2, only one error was recorded. This suggests that by the second test, participants had already developed a level of proficiency in using Wordwall, understanding its mechanics more effectively.

Based on these assertions, it can be inferred that the combination of mnemonic resources applied in this research and Nielsen's usability principles (1993) worked complementarily to enhance information retention. Together, these elements provide a strong foundation for explaining the observed 25% reduction in total errors.

From the perspective of information design, the results of this study reinforce the importance of structuring and presenting information in ways that facilitate comprehension and retention. Information design, as proposed by authors such as Pettersson (2010) and Tufte (1990), emphasizes clarity, organization, and the use of visual and textual elements to enhance cognitive processing. By integrating mnemonic tools—such as color, contrast, and audiovisual reinforcement, the study aligns with the theoretical framework that suggests well-structured information presentation aids memory and learning.

In the educational setting, this approach proves particularly valuable. The combination of visual design principles with cognitive psychology insights, such as those from Craik & Lockhart (2008) on semantic encoding, demonstrates how structured, meaningful information improves long-term retention. The integration of usability principles (Nielsen, 1993) further supports the argument that an intuitive and accessible digital environment enhances the learning process by reducing cognitive load and enabling learners to focus on the content itself.

Ultimately, this research underscores the role of information design as a facilitator of knowledge retention. By strategically using design elements to guide attention and reinforce meaning, the study supports the idea that effective information structuring enhances educational outcomes. The observed reduction in errors and improved performance over time highlights the effectiveness of applying information design principles in digital learning environments, reinforcing its relevance in instructional strategies.

This study presents limitations that must be acknowledged. First, the improvement in test results cannot be solely attributed to sleep; repetition, increased familiarity with the test interface, and environmental factors (such as group dynamics) may have also contributed. Participant 11, for instance, had an 83-day interval between tests, which is atypical and introduces a confounding variable. Additionally, the interface did not provide systematic feedback, which led to user confusion and could have impacted engagement. Future studies should control interval duration, repetition effects, and user interface feedback mechanisms to isolate the variables more clearly. Despite these constraints, the findings offer valuable insights into the interaction between mnemonic devices, usability, and information design in educational contexts.

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