Influence of Mnemonic Strategies on Brain Functions and Cognitive Processes in Students

By Catherine Chan

chan.sy.catherine@gmail.com

Abstract

Menemonic devices are memorization tools that can help you remember anything from mathematical formulas to phone numbers that otherwise would be much harder to remember (Pedersen, 2022). This is especially significant for students, because it can help them retrieve information that they would likely be tested on. This literature review aims to explore this topic by answering the question of how mnemonic strategies influence brain functions and cognitive processes related to memory in students. Key findings in this review are that students performed better with longer, phrase-based mnemonics in understanding and applying concepts, and students who reported using mnemonics were more likely to answer questions correctly. These findings mean that incorporating mnemonic techniques into language instruction can make vocabulary learning more engaging and effective, and imply that integrating mnemonics into teaching practices can benefit student understanding and confidence.

Introduction

Memory is an important aspect of learning that plays a critical role in students' academic success. This is why effective memory strategies are important for helping students retain and recall information more efficiently. Among strategies such as active recall and the Pomodoro Technique, mnemonic techniques such as acronyms and spatial methods, are also widely used to improve one's memory performance. Despite their commonality, there is still much to learn about how these strategies influence cognitive processes related to memory, and why they work as well as they do. Existing research suggests that mnemonic devices can increase activity in the hippocampus and prefrontal cortex, which leads to enhanced memory encoding and retrieval (Lee, 2025). Additionally, as individuals continue to use mnemonic devices, the associated brain

regions can go through changes in gray matter volume and connectivity due to a concept known as neuroplasticity, which can lead to improved memory long-term. Overall, these findings suggest the mnemonic strategies not only enhance memory performance, but also positively impact the brain's function long term. By understanding these effects, not only can students learn how to effectively study, but educators can also learn how to develop more effective methods to support student learnings and improve memory retention.

Methodology

This literature review was constructed using the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) method, which is a standardized framework used for systematic reviews. The first step of this method is to define a research question; this paper aims to investigate how mnemonic strategies influence brain functions and cognitive processes related to memory in students. Next, a systematic search was made across multiple databases with at least ten sources inserted into the first tab of the literature review matrix, which is a spreadsheet organizer of all the considered sources. The following information was recorded for each source: the author(s), the title, the journal it is published in, its key words and search terms, and its Digital Object Identifier (DOI) link. After this, each source went through the first screening. In the first screening, sources' titles and abstracts were analyzed and screened for four different inclusion criterias: publication type, publication date, publication language, and variables. After the initial screening, the included sources that passed this critical appraisal, would then move on to the second screening, which required for each study to be read fully. Once fully read, these sources were then analyzed for another four different inclusion criterias: study type, bias, insufficient reporting, and full text available. The last step of this method, using the articles that

passed through this second critical appraisal was data extraction. In this step, the following information was recorded from each study: the theme, study purpose, study design, year data collected, participants' information, the location of study, control variables, the study intervention, the results and conclusion, limitations, similarities and differences to existing literature, and lastly, personal notes and arising questions.

Results

Mnemonic methods/techniques

Teaching mnemonic techniques significantly improves high school students' knowledge and application of memory strategies, leading to better recall and learning outcomes. Firstly, in a descriptive-causal study at First High School in Celje, Slovenia, students' knowledge and usage of mnemonic techniques were assessed both before and after the intervention (Kozmus et al. 2023). This study's purpose was to assess high school students' knowledge and use of mnemonic techniques and explore their effectiveness in improving learning. The results were that after the intervention, students showed a significant increase in both their knowledge and use of mnemonic techniques, reported greater confidence in applying these strategies, and demonstrated improved recall in learning tasks. This proves that teaching mnemonic techniques in the classroom is an effective way to improve students' memory skills and learning outcomes. This study also adds to existing literature by emphasizing the application of mnemonic techniques in a real classroom setting with immediate pre- and post-assessment, whereas some previous research has focused more on laboratory or controlled experimental conditions.

Secondly, mnemonic acronyms can facilitate faster learning of complex sequences by helping individuals organize tasks hierarchically. In an experimental between-subjects study at Technische Universität Berlin in Germany, participants' knowledge test completion time, sequence errors, non-sequence errors, resumption time, post-interruption errors, interruption task performance, and subjective rating during post-experiment interview were all measured (Radović et al., 2019). This study's purpose was to see if using a mnemonic acronym can help people learn, perform, and recover from interruptions more easily when doing complex step-by-step tasks. It also looks at how the way the acronym is structured affects how people think about the task. The results were that participants supported with the mnemonic acronym learned the task faster than those without it, no significant differences were found between groups in overall speed or accuracy during uninterrupted task performance, and the mnemonic did not significantly improve resilience to interruptions in terms of shorter resumption times or fewer errors after interruptions. This proves that using a mnemonic acronym can help people learn complex sequences more quickly and may influence how they mentally organize tasks into parts. While it doesn't necessarily make the execution faster or more resilient to interruptions overall, structuring the acronym can improve performance at specific points in a task, especially at task boundaries. This study also adds to existing literature by emphasizing the importance of the structure within mnemonics in organizing task hierarchy, which is less explored in prior work, and investigates not just learning outcomes, and also the cognitive processes underlying task resumption after interruptions

Lastly, incorporating visual aids into vocabulary instruction can lead to significant improvements in learners' ability to recall and recognize new words. In a quasi-experimental study at Kish

Language Institute in Rasht, Iran, pre-tests and post-tests designed to assess participants' vocabulary knowledge through multiple-choice and matching questions evaluating the learners' ability to recall and recognize the target vocabulary (Farrokh et al. 2021). This study's purpose is to investigate how key word mnemonic vocabulary teaching can improve the reading comprehension of upper intermediate high school students in EFL classrooms. Specifically, it aimed to determine whether implementing mnemonic strategies enhances students' ability to understand, retain, and comprehend content material, thereby contributing to more effective language learning and reading skills. The results were that learners who used visual mnemonic techniques showed significantly greater improvement in vocabulary acquisition and retention compared to those who received traditional instruction. This proves that incorporating visual mnemonic techniques into vocabulary teaching can enhance learning outcomes for Iranian EFL learners across different age groups. These techniques facilitate better memorization and recall of new vocabulary, making them a valuable tool in language instruction. This study also adds to existing literature by focusing on both young and adult learners within a specific cultural and educational context, providing insights into age-related differences in the effectiveness of visual mnemonics. Also, it demonstrates the practical application of visual mnemonics in a real classroom setting in Iran, whereas many prior studies were conducted in Western contexts.

Mental cognitive skills/training

Mnemonic training can effectively reorganize brain networks, leading to lasting memory improvements that resemble those of memory experts. In a longitudinal experimental study at the MRI facilities at Max Planck Institute of Psychiatry in Munich, Germany, free recall tasks where participants memorized and later recalled lists of words to assess memory performance, number

of training sessions/runs to reach a specific level of word memorization, self-reports rating alertness and compliance during scans, and neuroimaging measurements were all recorded (Dresler et al., 2017). This study's purpose was to investigate how intensive mnemonic training influences the organization and connectivity of brain networks associated with memory performance. The results were that mnemonic training improved memory performance and induced widespread changes in brain connectivity, making participants' brain networks more similar to those of memory champions. These neural changes predicted memory gains and lasted for months. This proves that intensive mnemonic training can rewire brain networks to support superior memory, demonstrating brain plasticity and the potential for cognitive enhancement through targeted strategies. This study also adds to existing literature by showing that non-expert individuals can develop brain connectivity patterns similar to experts through training, therefore emphasizing the role of between-network connectivity during rest.

Additionally, analysis of post-test scores revealed that the mnemonic training group outperformed the control group, indicating the effectiveness of mnemonic strategies like keyword techniques. In a quasi-experimental study at six senior high schools in Zanjan, Iran, Cloze tests, specifically, the Cold War and Civil Rights unit Cloze assessments, were administered as pre-tests and post-tests to evaluate students' reading comprehension and vocabulary understanding (Faish et al. 2018). Data from these tests were analyzed using Covariance Analysis (ANCOVA) to determine whether there were statistically significant differences in reading comprehension scores between the control group and the experimental groups after controlling for pre-test scores. This study aims to investigate how key word mnemonic vocabulary teaching can improve the reading comprehension of upper intermediate

high school students in EFL classrooms. The results of this study were that students who received mnemonic vocabulary instruction demonstrated significantly greater improvements in reading comprehension compared to the control group that received traditional instruction. Statistical analysis using ANCOVA showed a significant effect of the mnemonic intervention on post-test scores, with the mnemonic group outperforming others after adjusting for pre-test scores. This proves that mnemonic vocabulary instruction, particularly using key word strategies, significantly enhances reading comprehension among upper intermediate high school students and increases motivation and engagement with vocabulary learning. This study also adds to existing literature by specifically targeting upper intermediate high school students and filling a gap in the literature regarding the effectiveness of mnemonic strategies at this educational stage. It also investigates students' and teachers' attitudes towards these strategies, providing insights into motivational factors that influence learning.

Method of loci

Given its simplicity, cost-effectiveness, and adaptability, the Method of Loci (MOL), a mnemonic device that relies on spatial relationships between "loci" or location to arrange and recall content from your memory, has the potential to be a valuable addition to teaching methods across various disciplines in medicine and health sciences. In a prospective randomized controlled educational intervention study in Rawal Medical College in Islamabad, Pakistan, student performance on a multiple-choice quiz (MCQ) administered at the end of the instructional session was measured to assess understanding and recall of the topics related to insulin and diabetes mellitus (Qureshi et al., 2024). This study's purpose was to investigate whether the use of the MOL, a mnemonic and spatial memory technique, can enhance medical

students' understanding, retention, and recall of complex physiological concepts related to insulin and diabetes mellitus. The results of this study were that students who learned insulin and diabetes mellitus using the MOL performed significantly better on the assessment quiz than those who studied through self-directed learning with worksheets. The MOL group achieved a higher mean score (9.31 out of 10) compared to the control group (8.10 out of 10), with the difference being statistically significant ($P < 0.003$). This demonstrates that the MOL is an effective mnemonic technique for improving memory retention, understanding, and active engagement in medical education. It not only enhanced students' assessment performance but also increased motivation and positive attitudes toward learning. This study also adds to existing literature by demonstrating the feasibility of implementing MOL with minimal resources, which is particularly relevant for educational settings with limited access to advanced tools or training.

Statistics education

Integrating simple, content-specific mnemonics into statistics teaching practices can benefit student understanding and confidence. In a large-scale educational survey-based quasi-experimental study in a large public research university in southeastern United States, student surveys assessing mnemonic usage, perceived helpfulness, and anxiety reduction were measured to determine the association between mnemonic use and question correctness (Mocko et al., 2017). This study's purpose was to assess students' use and perception of mnemonics, their effect on anxiety, and their influence on exam performance in introductory college statistics courses. The results of this study were that students believed mnemonics reduced test and learning anxiety, with a strong link between perceived helpfulness and anxiety reduction. On exams, students who reported using mnemonics were more likely to answer questions correctly,

especially for concepts like hypothesis testing and p-values. This leads researchers to conclude that using mnemonics in introductory statistics courses can help students remember key concepts, reduce anxiety, and improve exam performance. Overall, incorporating brief, content-related mnemonics into teaching may enhance learning outcomes and student confidence, especially in large, hybrid courses. This study also adds to existing studies because unlike previous research primarily focused on language learning or medical education, this study extends these findings to introductory statistics, highlighting their applicability in quantitative disciplines.

While students can often recall simple mnemonic devices, they face challenges in explaining and applying them effectively to statistics, therefore emphasizing how the depth of understanding and practical application of mnemonics in instruction can enhance learning outcomes. In a large-scale cross-sectional survey study at University of Florida, surveys assess students' recall, self-reported familiarity, ability to explain mnemonics when cued, and correct application of mnemonics on exam-like questions (Mocko et al., 2024). The aim of this study was to examine how students recall, understand, and apply mnemonics in introductory statistics courses, and to identify ways to improve their effective use in problem-solving. The results of this study were that students recalled acronym mnemonics more often, but longer phrase mnemonics were explained and applied better. Over time, familiarity and correct application showed mixed changes, but overall, students performed better with longer, phrase-based mnemonics in understanding and applying concepts. From this, researchers can conclude that instructors should focus on bridging this gap by providing support and context to help students move from recall to effective use. This study adds to existing studies because unlike some studies that focus solely on

recall, this research examined the full process from recall to application, highlighting the gap between knowing and doing. It also provides a comparison between acronym and phrase mnemonics, offering a unique perspective on how mnemonic complexity influences understanding and application.

Memory

Mnemonic-based teaching methods significantly improve the short-term memory retention of physiological concepts among medical students compared to traditional teaching approaches. In a prospective randomized controlled educational intervention study at the Department of Physiology, PIMS (Pius Institute of Medical Sciences), Thiruvalla, Kerala, India, the mean scores and percentages of correct responses before and after the intervention were compared and statistical analyses such as ANOVA and Dunnett's multiple comparison tests determined the significance of differences (Meenu et al., 2022). This study's aim was to compare the effectiveness of mnemonic-based text reading versus traditional teaching methods in improving memory retention and understanding of physiological concepts among medical students. The results were that the intervention group using mnemonic-based teaching showed a significantly higher mean score of 8.4 ± 0.24, indicating a strong improvement in knowledge retention. The control group without mnemonics had a lower mean score of 4.8 ± 0.37, suggesting no significant improvement. Due to this, researchers can conclude that mnemonic intervention-based text reading is more effective than traditional teaching methods in enhancing memory retention of physiological concepts among medical students. Incorporating mnemonics into teaching strategies can significantly improve students' understanding and recall of complex

medical topics. Lastly, this study adds to existing literature by emphasizing short-term memory improvement, unlike studies examining long-term retention.

Findings show that incorporating mnemonic techniques into language instruction enhances memory retention, making vocabulary learning more engaging and effective for learners overcoming the memory-related challenges of learning English. In an experimental classroom-based intervention study at Hubei University of Technology in Wuhan, China, participants were given vocabulary tests consisting of 5 multiple-choice questions where participants matched vocabulary words to their synonyms (Hill, 2022). The tests were scored on a 0-100 scale, and the difference in scores before and after the treatment indicated the effect of mnemonic techniques on vocabulary retention. The scores from the pre- and post-tests were compared by calculating the mean and individual score improvements to assess overall effectiveness. After the tests, participants completed surveys with closed and open-ended questions to determine their attitudes toward mnemonic devices and to identify which techniques they preferred. The purpose of this study is to determine which types of mnemonic techniques are most effective and preferred by learners, as well as to understand students' attitudes towards these memory aids with the goal of informing more effective vocabulary teaching strategies in the ESL classroom. The results were that 60% of participants scored perfectly on both pre- and post-tests, while some showed significant individual improvements, such as one participant increasing their score by 60%. Most participants reported positive perceptions of mnemonic devices, with 75% agreeing or strongly agreeing that mnemonics are fun and useful for studying. This can lead researchers to conclude that mnemonic devices can effectively enhance vocabulary retention among adult Chinese ESL learners. Participants not only improved their test scores but

also expressed favorable attitudes towards using mnemonics, finding them engaging and helpful. This study adds to existing literature by specifically examining adult university students in China, whereas much existing research targets younger learners or different language contexts, therefore adding valuable insights into adult language acquisition and memory.

Discussion

To assess the implications of these findings, it is first essential to assess the strengths and limitations. In looking at mnemonic techniques and their role in study learning, a pre- and post-intervention design allows for a clear evaluation of the intervention's effectiveness and the strategies' applicability across different age groups within high school (Kozmus et al., 2023). However, some limitations of this study design is that it relies on self–reported data for some measures which may be subject to bias or inaccuracies. In looking at neural plasticities and superior memory performance through mnemonic training, using a well-controlled and longitudinal design with training and control group allows for it to extend existing research on memory champions exhibiting distinctive brain connectivity patterns (Dresler et al., 2017). Still, the small sample size of memory athletes in this study limits the generalizability of these findings. Next, in a study of how structured mnemonic devices can support memory, incorporating both behavioral data and participants' self-reported strategies offering comprehensive insights into cognitive processes (Radović et al., 2019). However, for this specific study only focused on short-term learning and performance, therefore long-term effects of mnemonic use were not examined. In addition, a study on how mnemonic techniques improve language learning, a quantitative approach with pre- and post-tests offers insights for EFL instructors on how to improve vocab learning through direct mnemonic strategies (Hill, 2022).

Still, a lack of control group makes it difficult to attribute improvements only to mnemonic strategies versus other factors. In a study on mnemonics to improve learning and reduce anxiety in statistics education, though use of both survey data and exam performance provides comprehensive insights, like the study on mnemonic techniques and their role in study learning, using self-reported data may be subject to bias (Mocko et al., 2017). Next, in a study using mnemonics to improve statistical learning and application, one strength was focusing on both simple (acronym) and complex (phrase) mnemonics provided nuanced insights (Mocko et al., 2024). However, the results were limited by variability in student engagement and prior knowledge not being fully controlled. For a study on enhancing medical education through mnemonic-based teaching to improve memory retention, by systematically comparing mnemonic-based teaching with traditional methods, it provides clear evidence of effectiveness (Meenu et al., 2022). Yet, sample size was relatively small with 10 students per subgroup, which may limit generalizability. In addition, a study on the effects of visual mnemonics on vocabulary learning focusing on both young and adult learners helped to provide insights into the effectiveness of visual mnemonics across different age groups (Farrokh et al., 2021). However, this study did not explore other variables such as learner motivation, individual learning styles, or the influence of prior knowledge, which could impact the effectiveness of visual mnemonics. Next, in studying the effectiveness of mnemonic vocabulary instruction in enhancing reading comprehension, having a large sample size makes findings more reliable and generalizable to similar student populations (Fasih et al., 2018). Still, this study only involved male students limiting generalizability of results to female students. Lastly, in a study looking at the effectiveness of the Method of Loci as a mnemonic technique to enhance memory retention, using both quantitative and qualitative data allows the data collected to be integrated into

existing curriculum with minimal additional resources (Qureshi et al., 2024). A limitation about this study however is that the multiple choice questions used primarily assess recall rather than higher-order thinking, therefore limiting insight into deeper understanding.

Conclusion

Overall, analysis of post-test scores revealed that the mnemonic group outperformed the control group, indicating the effectiveness of mnemonic strategies like keyword techniques in enhancing vocabulary retention and understanding of content-related material. Additionally, findings advocate for the integration of visual mnemonic strategies into language teaching curriculum to optimize vocabulary acquisition outcomes. Most importantly, mnemonic training can effectively reorganize brain networks, leading to lasting memory improvements that resemble those of memory experts. This finding is important because it demonstrates the brain's plasticity and the potential for cognitive enhancement through targeted strategies. In summary, this research can help instructors take the next step in incorporating mnemonics into their teaching to improve the short-term memory retention of concepts compared to traditional teaching approaches. The potential next steps of this research is to experiment with what instructional techniques best support students in transitioning from memorization to application, and identify whether or not combining mnemonic strategies with other learning techniques produce even greater benefits.

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