

Fostering Vocabulary Memorization: Exploring the Impact of AI-Generated Mnemonic Keywords on Vocabulary Learning Through Anki Flashcards

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Received: November 8, 2023 Accepted: January 2, 2024 Online Published: February 5, 2024

doi:10.5430/wjel.v14n2p434 URL: <https://doi.org/10.5430/wjel.v14n2p434>

Abstract

This study delves into the integration of AI-generated mnemonic assistance in Anki flashcards, aiming to enhance vocabulary acquisition for intermediate-level English language learners who often grapple with vocabulary challenges. The research involved a sample of 60 students, split into two groups: the Mnemonic group, which used Anki flashcards with AI-generated mnemonics, and the Non-Mnemonic group, which relied on Anki flashcards without mnemonics. The findings revealed that both groups exhibited statistically significant vocabulary retention improvements after undergoing four repetition sessions. Significantly, the Mnemonic group displayed a more pronounced enhancement, underscoring the effectiveness of AI-generated mnemonic support. This research amalgamates insights from cognitive psychology, spaced repetition techniques, and AI-driven personalization to offer a comprehensive and adaptive approach to vocabulary acquisition. Its implications extend to educators, learners, and the ongoing evolution of language instruction, as it highlights the potential for AI to play a pivotal role in addressing the persistent challenges associated with vocabulary acquisition, especially among intermediate-level English language learners.

Keywords: vocabulary learning, Anki flashcards, mnemonics, Artificial Intelligence (AI), spaced repetition

1. Introduction

1.1 Introduce the Problem

Developing a robust vocabulary constitutes a pivotal aspect of language acquisition. The ability to grasp a new language hinges not only on one's comprehension of its grammar and syntax but also on their mastery of an extensive lexicon. Both scholars and educators have harboured a profound interest in the effectiveness of methods for acquiring vocabulary. The amalgamation of artificial intelligence (AI) with cutting-edge pedagogical approaches has unveiled novel avenues for enhancing language learning in this age of technology-driven education. This study aims to explore the substantial impact of incorporating AI-generated mnemonic keywords into the well-established Anki flashcards technique for vocabulary acquisition.

Traditional language learners have, for quite some time, made use of various mnemonic techniques to aid in the retention of new terminology. Techniques such as acronyms, rhymes, and visualization have been harnessed to assist individuals in remembering words. These methods have been effective, although they typically rely heavily on the learner's own imagination and cognitive abilities. Their effectiveness across a wide range of student populations may occasionally be hampered by this dependence. The capability of artificial intelligence (AI) to identify patterns, adapt to user needs, and generate personalized mnemonic aids opens up new possibilities for standardising and enhancing vocabulary learning mnemonic methods.

A well-known digital flashcard program called Anki is known for its sterling reputation in helping people learn new words. Its foundation is spaced repetition, a method based on memory psychology that carefully considers when material should be reviewed to increase retention. Flashcard decks with word and phrase lists for language learning can be made and shared by Anki users. However, coming up with mnemonic aids for every word in a language may be a laborious and time-consuming task that frequently requires more creativity than the typical learner is capable of.

The challenge should be lessened thanks to the interaction between Anki and AI. Mnemonic keywords can be quickly created by AI based on the distinctive qualities and associations of each word, potentially improving the speed and efficacy of vocabulary learning. A highly personalized learning experience is provided by AI-generated mnemonics, which can be adjusted to the learners' competence levels, preferences, and cognitive styles.

The effect of AI-generated mnemonic keywords in the context of Anki flashcards is being investigated by this study, representing a new contribution to the field of language training. The study will examine whether regular Anki flashcards without mnemonics when paired with AI-generated mnemonics, result in a noticeable improvement in vocabulary memory. Furthermore, an inquiry will be conducted to determine whether this technique is of particular benefit to intermediate English language learners (ESLs), who often contend with challenges in vocabulary acquisition. The study discussed here builds upon the foundation laid by cognitive psychology, educational technology, and the evolving field of artificial intelligence in learning. By examining the synergy between these categories, important gaps in current vocabulary acquisition approaches are sought to be filled, with the potential to open up a more effective and efficient path for language learners. Insights that are not only theoretically valuable but also immediately applicable in the field of language instruction will be aimed for through empirical analysis and a well-structured research strategy. The calibre of language learning experiences may ultimately be improved, and this research could have far-reaching effects on language teachers, instructional designers, and language learners striving to achieve fluency in a new language.

The application in use is ANKI, designed primarily for vocabulary acquisition. Students have the flexibility to create flashcards for target words, customizing meanings based on their comprehension. They can enhance the cards by adding more clues or simplifying language, and even incorporate mnemonic keywords related to their mother tongue. This adaptability caters to English Language Teaching (ELT) students, particularly those learning a second language. The research focused on gauging the efficacy of ChatGPT-generated mnemonic clues and introducing a self-operable learning platform. Flashcards were pre-prepared, allowing students to independently utilize them in their learning process. The research paper proceeds to give a concise overview of the theoretical aspects of the study, a comprehensive literature review explaining the different approaches with which the model has been approached so far along with methodology, findings, and discussion of the results. The innovative approach will open new opportunities for students and educators. Language experts and researchers are bound to examine AI and its innumerable possibilities in language learning.

In the post-COVID-19 era, students have transitioned into a tech-centric age, striving for convenient and paperless learning experiences. While the use of flashcards is an age-old and respected practice, integrating technology has significantly enhanced its accessibility. This application can be easily downloaded on mobile phones, providing students with the flexibility to learn from the comfort of their homes. Moreover, the majority of students possess smartphones, tablets, or sometimes computers, all of which are commonly found in households.

Additionally, for situations where technology may not be readily accessible, instructors can still deliver concepts using downloadable flashcards. This flexibility ensures the effectiveness of the learning tool, catering to students with varying levels of access to technological resources.

2. Literature Review

2.1 Comparative Analysis of Mnemonic and Non-Mnemonic Vocabulary Learning Strategies

Research on vocabulary learning strategies reveals a nuanced landscape, often shaped by learner preferences and contextual influences (Levin, 1982; Mastropieri et al., 1985; Yang & Dai, 2012). One prominent mnemonic strategy, the keyword method, stands out for its efficacy in enhancing vocabulary acquisition, particularly in children and learning-disabled students (Mastropieri et al., 1985) findings reinforce the superiority of the keyword method over the context method in both immediate and delayed recall and recognition of vocabulary. Anjomafrouz and Tajalli's (2012) study further highlights the benefits of mnemonic devices, specifically among adult and teenage EFL students. The comparison of mnemonic associations with repetition underscores the superior performance of the mnemonic group. Marzban and Amoli (2012) delve into the realm of mnemonics to remember previously learned words, demonstrating success among students at the Aviation University of Tehran. The experimental group, employing mnemonic image and visualization techniques, outperforms the control group in both short-term and long-term memory retention. Similarly, Safa and Hamzavi (2013) emphasize the effectiveness of the Mnemonic Keyword method, showcasing superior performance compared to repetition memory techniques among EFL students. Cohen (1987) analysed the effectiveness of mnemonic associations in vocabulary acquisition for second-language learners. He explained the keyword approach, which involves creating an acoustic link between a native-language word and a second-language word, as well as an image of the keyword interacting with the native-language word or phrase. Cohen highlights the potential benefits of mnemonic strategies in language learning, while also acknowledging the need for further research in this area. Verbal and imagery mnemonics, particularly the keyword approach, can enhance second-language vocabulary learning and recall. In a study conducted by Levin et al. (1982), the researchers compared mnemonic and Non-Mnemonic vocabulary-learning strategies for fourth-grade students. The results revealed that students in the keyword context condition outperformed those in the control context condition. This finding suggests the effectiveness of the keyword method in enhancing elementary school children's recall of complex vocabulary definitions. The study indicates that mnemonic strategies, such as the keyword method, may be beneficial for teaching vocabulary to children. The extensive examination of the keyword method includes research by Sagarra and Alba (2006) and Zheng Wei (2014), offering support for its efficacy over rote memorization, semantic mapping, and word-part techniques. However, Zheng Wei's study introduces a note of caution, revealing that not all studies consistently find the keyword method superior, as seen in the comparison with the word-part technique.

The literature also explores the potential integration of augmented reality (AR) to enhance the keyword method, as inspired by works from Vazquez et al. (2014), and Ibrahim et al. (2009). This innovative approach combines AR with animated visualizations of keywords to advance vocabulary learning beyond traditional methods (Shapiro & Waters, year). The integration aims to leverage visual imagery for enhanced vocabulary acquisition. In summary, the literature on vocabulary learning strategies, with a specific focus on the Mnemonic Keyword method, reveals varying effectiveness influenced by learner preferences, contextual factors, and specific mnemonic approaches. The comparison between mnemonic and Non-Mnemonic strategies underscores the multifaceted nature of vocabulary acquisition, encouraging further exploration and a nuanced understanding of their differential impact on vocabulary development.

A myriad of challenges in vocabulary learning has prompted the development of innovative study models. First and foremost, the intricate nature of memory processes—encoding, consolidation, and retrieval—which are critical for acquiring new words, is often grappled with by learners. This cognitive challenge emphasizes the necessity for effective strategies to facilitate these processes. Additionally, the limitations of learners' capacity for processing information, as revealed by cognitive load theory, underscore the risk of overwhelming students with vocabulary materials (Asma & Sarnou, 2020). This overload can potentially hamper the learning experience. Additionally, students are often challenged by the retention and recall of new words over the long term, with vocabulary frequently slipping from memory shortly after the initial exposure. Traditional methods may play a role in contributing to the issue of engagement and motivation, as learners often perceive vocabulary learning as dull and uninspiring (Cornejo & Yuleisi, 2016). Furthermore, the absence of personalized learning approaches neglects individual differences in learning pace and preferences, thereby further hindering the effectiveness of vocabulary acquisition. The uneven access to high-quality vocabulary resources is another concern, particularly impacting learners with geographical and financial limitations. Many cases involve learners facing challenges related to the lack of timely feedback and reinforcement, rendering it difficult to correct errors and reinforce correct responses. The emergence of AI-driven educational technologies, in this context, emphasizes the necessity of exploring their potential for optimizing vocabulary learning and, consequently, addressing these challenges. The shift towards mobile and online learning platforms, while offering both opportunities and challenges, brings about alterations in the traditional landscape of vocabulary acquisition. Engaging in interactive methods that actively

involve learners in the learning process is deemed essential for maintaining interest and enhancing memory. The promise of addressing the diverse needs of students at different levels through the development of adaptive, personalized learning approaches is acknowledged. These issues underscore the significance of innovative study models, such as the one outlined in this research, which integrates cognitive psychology, spaced repetition, digital flashcards, and AI algorithms to provide solutions to these longstanding issues in vocabulary learning.

2.2 Cognitive Psychology Perspective: Memory and Learning

The central principle of this system revolves around cognitive psychology, which acknowledges the intricate nature of memory encoding, consolidation, and retrieval processes essential for acquiring new words. The framework not only acknowledges the importance of these processes but also delves into the cognitive mechanisms governing encoding, consolidation, and retrieval. It offers valuable insights into enhancing these mechanisms for more effective learning.

This research focuses on memory systems, emphasising the investigation of cognitive mechanisms influencing encoding, consolidation, and retrieval. It incorporates ideas from cognitive psychology. It aims to clarify how these systems may be improved still further to provide better learning outcomes. The Cognitive Theory of Multimedia Learning (CTML) and Computer-Assisted Vocabulary Learning (CAVL) applications serve as the study's cornerstone.

Three presumptions are outlined within the CTML framework, which is a theoretical paradigm for multimedia-based learning put forth by Mayer in 2005. In the opening, Mayer observes that the brain processes information through two distinct channels: one dedicated to verbal information and another to visual information. Furthermore, the idea that each channel has a limited capacity is derived from the Cognitive Load Theory (CLT). The research described here is further supported by the dual coding hypothesis (Paivio, 1986) through the utilization of mnemonic assistance. By using mnemonic assistance, the dual coding theory (Paivio, 1986) comes into play in this research. This theory suggests that there are two primary ways our brains encode and remember information: through words and images or mental pictures. Even though both CTML and Dual coding theory seem like they are interrelated, their focus on learning and memory are slightly different. Slightly different from the effectiveness of using CAVL in recognising new information. The major difference lies in their emphasis and focus. While Dual coding theory is more concerned with the nature of memory representation and how combining words and images can enhance learning, the CTML theory, on the other hand, is more specific to how multimedia materials should be designed for effective learning.

2.3 Digital Flashcards and Spaced Repetition

Anki Flashcards and spaced repetition are based on the concept of active recall, which is the process of retrieving information from memory. The idea behind spaced repetition is to make the brain work harder to remember the material by stretching the time between review sessions. This improves long-term retention by reinforcing neural connections.

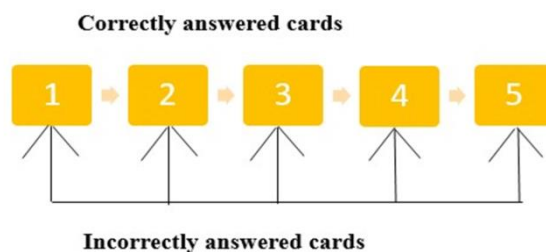


Figure 1. Spaced Repetition framework

Spaced repetition is a technique used for systematically reviewing and reinforcing knowledge. Initially, the content is reviewed briefly, possibly once every hour, once every four hours, or once every day. Over time, these intervals are gradually extended, reaching durations of four days, one week, and two weeks. The primary aim of spaced repetition is to ensure that the content is revisited just before it is on the verge of being forgotten, with the goal of aiding its retention in long-term memory. This approach has been found to be more effective than continuously reviewing the information within a single study session. Spaced repetition diminishes the memory decline that occurs when the material is not revised for prolonged periods. By necessitating the active recall of previously learned content, this method actively fosters the learning process. Furthermore, if something is forgotten, it prompts the utilization of more effective learning methods to ensure that the information is retained for future evaluations (Spaced Repetition: Remembering What You Learn, 2015). Research has shown that spaced repetition can significantly improve retention and recall of information. The value of digital flashcards as an alternative to conventional resources emphasizes the benefits of incorporating them into collaborative learning tasks (Puglla & Cesibel, 2015; Hung, 2015). Xodabande and Atai (2022) compare digital and paper-based flashcards and conclude that learning with digital flashcards on mobile devices leads to significant improvements in vocabulary knowledge. Computerized flashcards have always proved to be effective teaching tools in the classroom to aid students in learning vocabulary (Byrd & Lansing, 2016). Flashcards are quite effective because they promote the act of repetition. Flashcards are recommended to teach vocabulary to young learners as they make students more active, happy, and enthusiastic in learning English vocabulary (Sitompul, 2013). The Spacing Effect stresses the fact that knowledge retention is enhanced when information is revisited at intervals spaced further apart. Spaced repetition and targeted mnemonic strategies greatly facilitate the learning process and foster long-term recall (Mubarak & Smith, 2008; Russo et al., 1998). The framework aims to leverage the science of memory to enhance language retention by implementing this concept. Mnemonic devices such as acronyms, visualization, and rhyme are integrated into the flashcard design to provide students with effective tools for encoding and retrieval, ultimately improving language retention (Weerasinghe et al., 2022; Amiryousefi & Ketabi, 2011). Utilizing online flashcards as a digital tool for delivering the vocabulary learning experience is a central feature of the framework. Online flashcards offer a well-organized platform for the presentation and review of vocabulary items. These digital cards empower learners to interact with the content in a flexible and easily accessible manner. Digitized flashcards on mobile devices proved beneficial for advanced English learners, enhancing their vocabulary

acquisition (Nikoopour, 2014). The integration of flashcards into online instruction also yielded positive effects on vocabulary learning, particularly for intermediate-level learners (Khan, 2022). Kaplan-Rakowski (2017) examined learners' perspectives and revealed that specific multimedia elements, such as translation features, were recognized as valuable tools for vocabulary improvement when utilizing digital flashcards. Learners themselves engage with online flashcards, which can include features such as flipping to reveal definitions, shuffling to challenge memory recall, and self-assessment to measure their progress. These interactive components heighten engagement and foster effective learning. The feedback mechanisms within the online flashcard system aid in immediate correction and reinforcement. They serve to enhance the learning process by providing learners with timely guidance and support, facilitating the correction of errors, and reinforcing correct responses.

AI algorithms are used to tailor the educational process. The AI system customises flashcard space and information based on the needs and development of each learner. By tailoring content and repetition times to each learner's unique needs and learning pace, this personalised method maximises the learning experience. AI is an intelligent system utilizing machine learning to dynamically schedule assignments and educational activities tailored to individual students' needs and preferences (Fernandes et al., 2023). It evaluates students' experiences using AI-generated personalised learning materials, highlighting the need to ensure successful personalization. (Draxler et al., 2023). AI systems can be considered personalised e-learning systems that aid in students' performance and knowledge to deliver customized content and enhance their learning capabilities. (Popescu & Bădică, 2011; Sree et al., 2019).

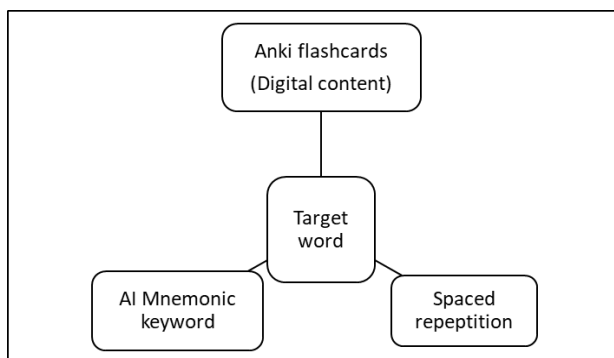


Figure 2. Research Framework Model

The inculcation of AI, into digital aids of learning allows for continuous improvement, with ongoing enhancements guided by feedback loops from students, educators, and AI analytics. This iterative process ensures the framework remains adaptable to evolving learner needs and the rapidly advancing realms of educational technology and AI. It integrates insights from cognitive psychology, educational technology, and artificial intelligence to provide a rich and personalized learning experience for vocabulary acquisition. It leverages memory and learning principles, the spacing effect, mnemonic techniques, interactive online flashcards, and AI-driven personalization. The framework's adaptability and iterative nature ensure it remains responsive to evolving learner needs and the advancements in educational technology and AI. By employing both quantitative and qualitative data analysis, the current study seeks to unveil the hidden aspects of differences with a comprehensive and precise approach. This study is imperative due to the limitations of past research, which confined itself to either quantitative or qualitative methods when addressing similar research questions. These studies failed to conduct a meticulous qualitative exploration of the problem, thereby overlooking the subtlest nuances. In this study, the effectiveness of Anki flashcards in vocabulary learning with AI-generated keyword assistance is compared with using Anki flashcards alone without AI assistance. To address the goal of the study, two research questions have been formulated.

1. Do the participants in both the Mnemonic group (those who used Anki flashcards with AI-generated mnemonics) and the Non-Mnemonic group (those who used Anki flashcards without mnemonics) exhibit statistically significant improvements in vocabulary retention after the four repetition sessions?
2. Is there a significant difference in vocabulary retention between the Mnemonic group (those who used Anki flashcards with AI-generated mnemonics) and the Non-Mnemonic group (those who used Anki flashcards without mnemonics) among intermediate-level ESL learners?

Addressing these research queries will provide valuable insights into the effectiveness of the framework's approach to vocabulary acquisition and its potential impact on the learning outcomes of ESL learners

3. Methodology

Selection Criteria: The participants selected for this study are 126 undergraduate students from an Engineering College in Tamil Nadu, India who are non-native speakers of English. To guarantee the homogeneity of the samples and to fulfil the objectives of the study, the Duolingo English Test (DET) was conducted and students whose score scale ranges from 60-85 that fall under the B1 CEFR level were selected for the study. A total of 63 participants were selected, of which 3 students were excluded as they were absent for 2 to 3 sessions.

The 60 students are divided into two groups

1. Mnemonic group (n=30): Given Anki flashcards supplemented with AI-generated mnemonics
2. Non-Mnemonic group (n=30): Given Anki flashcards without mnemonics.

Vocabulary List: Both groups are tasked with learning a set of 50 English vocabulary words selected over four sessions. The students attended the practice sessions as well as the review sessions. The time spent for vocabulary learning sessions was five hours and the review sessions were conducted for three hours. The vocabulary selected for the study were academic words selected from Cambridge Vocabulary for IELTS by Pauline Cullen (2012b).

Anki (Elmes, 2006) is an intelligent flashcard system that is based on the idea of space repetition. It gives a better and more comprehensive idea of the topics or ideas that the student needs to work on more and what is clearly understood and learned. Anki is free software that can be easily accessed through mobile or PCs (personal computers). For the research, the software was installed on PCs in the language lab with preprepared flashcards for both groups to control the practice and review time. Every single word that needs to be learned was added in 'Decks.' There will be a separate deck for each word. Under each deck, there will be 3 flashcards for the Non-Mnemonic group and 4 flashcards (an additional flashcard with keywords or images) for the Mnemonic group to reinforce the idea. The mnemonic keyword is generated by the ChatGPT (OpenAI,2023) system, which is an AI-based chatbot where the prompt given was to generate a 'phonologically' similar mnemonic keyword.

By using multiple flashcards for a single word, learners can reinforce their understanding and memory of that word from different angles, which can lead to more effective vocabulary retention

The flashcards provided for the Non-Mnemonic group include variations like-

- 1) A flashcard showing the word in isolation with its definition.
- 2) A flashcard presenting the word in a sentence.
- 3) A flashcard for providing the synonym or antonym for the word.

By using multiple flashcards for a single word, learners can reinforce their understanding and memory of that word from different angles, which can lead to more effective vocabulary retention

For the Mnemonic group where AI mnemonic assistance was provided along with the Anki flashcards, the Image Occlusion tool for Anki was also added for a few words and phonologically similar AI-generated mnemonic keywords or images were added to the flashcards. The flashcards provided for the Mnemonic group are -

- 1) A flashcard showing the word in isolation with its definition.
- 2) A flashcard presenting the word in a sentence.
- 3) A flashcard for providing the synonym or antonym for the word.
- 4) A flashcard offering a mnemonic or memorable association for the word.

In a single practice session that lasted for an hour, a total number of 10 words were introduced, learned, and practised by both groups. In the next session, the same words from the previous session were again revised and repeated, a form of space repetition technique, by going through the flashcards. This is a common practice in vocabulary learning and a form of memorization. Each flashcard presented the same vocabulary word in a different context or with a different focus, which helps learners gain a deeper understanding and better retention of the word. After introducing the 50 target words, the students were asked to go through the flashcards and try and memorise as much as possible. The introduction class lasted for a period of 90 minutes. There were 4 repetition sessions and the sessions lasted for 1 hour. The first session was on the next day after the initial learning session followed by a second repetition which was 3 days after the initial learning session. The third repetition was done on the 7th day and the fourth repetition on the 21st day after the initial learning session. The total time taken for intervention was 5 hours and 30 minutes inclusive of the introductory session.

Data Collection: The researcher administered a vocabulary achievement test as both a pre-test and post-test. The researcher created corresponding answer keys and conducted item analysis, resulting in a reliability coefficient of 0.72. The validity of the achievement test was evaluated by a language assessment specialist and an expert educator in the related domain. The test to be implemented was made ready after minor modifications to a few questions incorporating the suggestions from the review. The researcher employed 20 multiple-choice questions, 10 cloze test questions, 10 choose the right synonym and 10 sentence construction questions in the items. The test was conducted for a total mark out of 50. The selected vocabulary questions in the test were designed for middle school students with the goal of assessing both their receptive and productive vocabulary skills. Students are given a duration of one hour to finish the test. The pretest was conducted in the beginning before the practice sessions while the post-test was conducted after the 4 repetition sessions. Following the completion of the experimental study, a questionnaire was disseminated among the participants to gauge their overall sentiments and perspectives regarding the utilization of the novel application. Responses were gathered from both Mnemonic and Non-Mnemonic groups.

4. Results

The data analysis was carried out using IBM SPSS Statistics (Version 29). To analyse if ANKI flashcards could make an improvement in vocabulary retention among students from within the groups, a paired sample t-test was conducted. To examine which of the two sets of students, the mnemonic group or the Non-Mnemonic group performed better in helping the students' vocabulary, an independent sample t-test was administered by analysing the post-test data of both groups.

Table 1. Flashcard usage data of 30 students in the Non-Mnemonic group

Participants	Flashcards Reviewed	Pretest	Post-test
1	90	28	35
2	90	22	37
3	90	19	43
4	90	24	40
5	90	26	36
6	90	30	42
7	90	28	39
8	90	25	38
9	90	20	37
10	90	18	35
11	90	17	32

12	90	26	40
13	90	24	43
14	90	30	37
15	90	22	38
16	90	31	43
17	90	25	37
18	90	22	38
19	90	18	33
20	90	21	38
21	90	32	42
22	90	23	41
23	90	24	42
24	90	33	43
25	90	24	36
26	90	27	39
27	90	16	33
28	90	16	32
29	90	29	41
30	90	30	44

Table 2. Flashcard usage data of 30 students in the Mnemonic group

Participants	Flashcards Reviewed	Pretest	Post-test
1	120	26	40
2	120	25	40
3	120	21	39
4	120	23	43
5	120	23	42
6	120	24	40
7	120	21	42
8	120	23	42
9	120	26	44
10	120	26	45
11	120	19	39
12	120	22	40
13	120	25	42
14	120	31	45
15	120	28	43
16	120	26	42
17	120	25	43
18	120	25	41
19	120	22	40
20	120	23	41
21	120	24	42
22	120	24	43
23	120	18	39
24	120	22	41
25	120	28	44
26	120	23	41
27	120	25	41
28	120	28	44
29	120	30	46
30	120	26	44

4.1 Data Analysis

Table 3. Mean Pre-test scores and Standard Deviation of Non- Mnemonic and Mnemonic group

Group	Mean Pretest Score	Standard Deviation
Non-Mnemonic	24.33	4.86
Mnemonic	24.40	2.93

Table 4. Mean Post-test scores and Standard Deviation of Non- Mnemonic and Mnemonic group

Group	Mean Post-test Score	Standard Deviation
Non-Mnemonic	38.46	3.51
Mnemonic	41.93	1.91

To analyse if participants in both the Mnemonic group (those who used Anki flashcards with AI-generated mnemonics) and the Non-Mnemonic group (those who used Anki flashcards without mnemonics) show a statistically significant improvement in vocabulary learning after the intervention, a paired samples t-test is used to compare the pre-test and post-test scores within each group.

Table 5. Mnemonic group Paired Samples Statistics

T-Test

	Mean	N	Std. Deviation	Std. Error Mean
Pair 1 M. Pretest scores	24.4000	30	2.93140	.53520
M.Post-test scores	41.9333	30	1.91065	.34883

Paired Samples Correlations

	N	Correlation	Significance
			One-Sided p Two-Sided p
Pair 1 M. Pretest &M. Post-test	30	.775	<.001 <.001

Paired Samples Test

Paired Differences

		95% Confidence Interval of the Difference								
	Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	One-Sided p	Two-Sided p	
Pair 1	M. Pretest- M. Post-test	17.53333	1.88887	.34486	-18.23865	-16.82802	-50.842	29	<.001	<.001

On average, the Mnemonic group reported a mean difference of -17.5333 in the paired sample t-test. The negative sign suggests the treatment administered was effective, as the post-test scores exceeded the pretest scores. The calculated t-value of -50.842 further supports this finding, indicating that the post-test scores significantly surpassed the pretest scores. At a significance level of 0.05 and with 29 degrees of freedom, the critical value is determined to be 2.045. Given that the t-value (-50.842) far exceeds the critical value, the effectiveness of the treatment is highly significant.

t-value > critical value

50.842 > 2.045

Consequently, the mean difference of -17.5333 is statistically significantly different from zero. Also, the larger t-value (-50.842) is an indication that the difference is more pronounced between the paired samples. This difference specifies the idea that the treatment was effective. The p-value here is less than .001 which is less than 0.05.

P-value < 0.05

.001 < 0.05

The statistical analysis indicates a significant deviation from zero for the mean difference, confirming that the mean difference of -17.533 is significantly different from zero. The 95% Confidence Interval of the Difference shows that both lower and upper interval values are negative (Lower= -18.23865, Upper=-16.82802), which means they are both on the same side of zero and do not include zero.

Therefore, it can be confidently concluded that there exists a statistically significant variance in vocabulary retention when comparing the pretest and post-test scores of the Mnemonic group, who employed Anki flashcards with mnemonic support. This difference signifies a substantial improvement in vocabulary retention among the students in both the mnemonic and Non-Mnemonic groups after the intervention period.



Figure 3. Student Performance Improvement with Mnemonic Technique

Table 6. Non-Mnemonic group Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	NM Pretest Scores	24.3333	30	4.86602	.88841
	NM Post-test Scores	38.4667	30	3.51090	.64100

PAIRED SAMPLES CORRELATIONS

		N	Correlation	Significance	
				One-Sided p	Two-Sided p
Pair 1	NM Pretest & NM Post-test	30	.659	<.001	<.001

PAIRED SAMPLES TEST

		Mean	Std. Deviation	Std. Error Mean	95% Interval Difference		t	df	One-Sided p	Two-Sided p
					Lower	Upper				
Pair 1	NM Pretest- NM Post test	-14.13333	3.67408	.67079	-15.50526	-12.76141	-21.070	29	<.001	<.001

Research Question-1.

Non-Mnemonic group

The Non-Mnemonic group exhibited a significant decrease with a mean difference of -14.1333, indicating a substantial change in the measured variable. The negative sign indicates that the post-test scores surpass the pretest scores, underscoring the effectiveness of the administered treatment. The computed t-value of -21.070 further emphasizes this trend, indicating a substantial increase in post-test scores compared to pretest scores. Moreover, at a significance level of 0.05 and 29 degrees of freedom, the critical value stands at 2.045. The significantly higher t-value demonstrates a substantial deviation from the critical value, reinforcing the effectiveness of the treatment administered to the Non-Mnemonic group.

t-value > critical value

$$21.070 > 2.045$$

Consequently, the mean difference of -14.1333 is statistically significantly different from zero. Also, the larger t-value (-21.070) is an indication that the difference is more pronounced between the paired samples. This difference specifies the idea that the treatment was effective. The p-value here is less than .001 which is less than 0.05.

P-value < 0.05

$$.001 < 0.05$$

The mean difference of -14.133 demonstrates a statistically significant deviation from zero. Hence, it is confirmed that the difference of -14.133 is statistically significant. In simpler terms, the 95% Confidence Interval of the Difference does not contain zero, indicating that there is a statistically significant difference between the two groups being compared. (Lower= -15.50526, Upper=-12.76141)

Consequently, we can infer that the Non-Mnemonic group students exhibited a statistically significant improvement in their scores from the pretest to the post-test, indicating that the treatment had a positive effect. Therefore, based on the analysis, it can be confidently concluded that the Non-Mnemonic group, consisting of students who used Anki flashcards without mnemonics, showed a statistically significant improvement in vocabulary retention after the treatment.

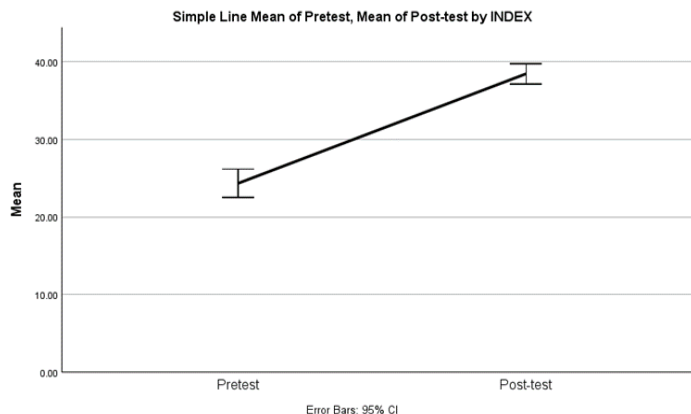


Figure 4. Student Performance Improvement with Non-Mnemonic Technique

Research Question-2

In order to understand if there was a significant difference in vocabulary retention between the Mnemonic group and the Non-Mnemonic group, an independent sample t-test was administered. The mean post-test scores of the two groups were compared as part of this statistical analysis.

Table 6. Independent Samples Test Comparing The Post-Test Scores Of Mnemonic And Non-Mnemonic Groups

GROUP STATISTICS

Group Statistics					
	N	Mean	Std. Deviation	Std. Error Mean	
Non- Mnemonic	1.00	30	38.4667	3.51090	.64100
Mnemonic	2.00	30	41.9333	1.91065	.34883

Independent Samples Test Comparing The Post-Test Scores Of Mnemonic And Non-Mnemonic Groups

Independent Samples Test	Levene's Test for Equality of Variances		t-test for Equality of Means							
	F	Sig	t	df	Significance	Mean Difference	Std. error Difference	95% Interval Difference	Confidence of the Difference	
										One-sided p
Equal Variances assumed	11.414	.001	-4.750	58	<.001	<.001	-3.46667	.72977	-4.92746	-2.00587
Equal Variances not assumed			-4.750	44.792	<.001	<.001	-3.46667	.72977	-4.93669	-1.99664

Independent Samples Effect Sizes

VAR00002		Standardizer ^a	Point Estimate	95% Confidence Interval	
				Lower	Upper
	Cohen's d	2.82639	-1.227	-1.775	-.669
	Hedges' correction	2.86361	-1.211	-1.752	-.660
	Glass's delta	1.91065	-1.814	-2.493	-1.119

a. The denominator used in estimating the effect sizes.

Cohen's d uses the pooled standard deviation.

Hedges' correction uses the pooled standard deviation, plus a correction factor.

Glass's delta uses the sample standard deviation of the control (i.e., the second) group.

The F value of 11.414 and a significance level (sig) of 0.001 indicate strong statistical significance. The sig value, smaller than the conventional 0.05 threshold, demonstrates the test results' robust statistical significance. Similarly, the t-statistic of -4.750, along with both one-sided and two-sided p-values less than 0.001, provides compelling evidence against the null hypothesis. This suggests a significant disparity in means between the two groups. Additionally, the 95% confidence interval, which does not include zero, further confirms the significant difference between the groups. The mean difference of -3.46667 emphasizes that the Non-Mnemonic group mean is significantly lower than that of the Mnemonic Group. These outcomes underscore a noteworthy distinction in vocabulary retention between the mnemonic and Non-Mnemonic groups among intermediate-level ESL learners.

In summary, the results of the independent samples t-test unequivocally demonstrate a substantial and statistically significant difference in vocabulary retention. Specifically, the Non-Mnemonic group exhibits a significantly lower mean than the Mnemonic group, indicating the effectiveness of mnemonic techniques in enhancing vocabulary retention among intermediate-level ESL learners.

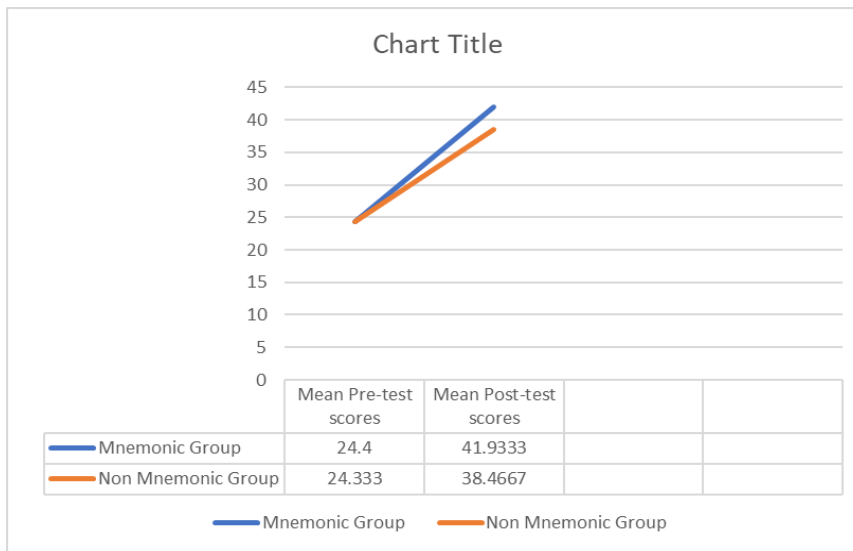


Figure 5. Comparing Mean Pretest- Post-test scores of Mnemonic group with Non-Mnemonic group

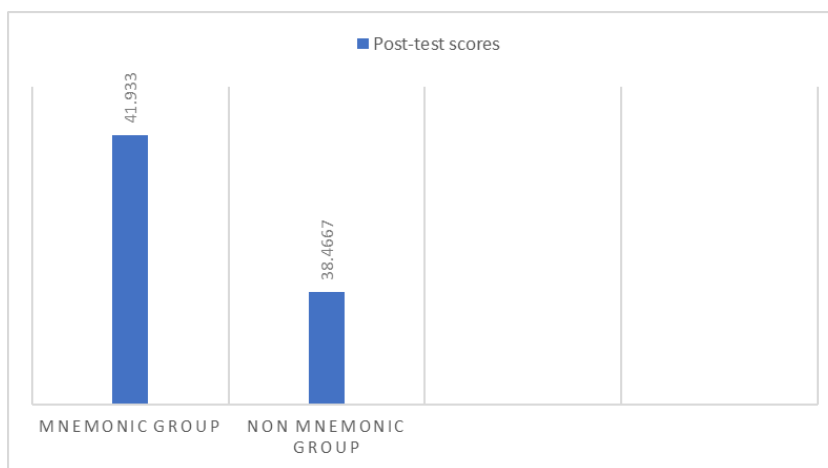


Figure 6. Comparing Post-test scores of the Mnemonic group with Non-Mnemonic group

4.2 Results from the Survey Questionnaire

A survey was administered following an experimental study involving participants from both groups. The aim was to gain insights into their perceptions and to assess their overall experience with an application designed to facilitate learning. Additionally, the survey sought to explore whether students are receptive to independently using technology for mastering challenging aspects of their education, such as vocabulary acquisition in the context of English Language Teaching (ELT).

No	Questions	Yes (%)	No (%)
1	Do flashcards aid your vocabulary learning during the study sessions?	81.66	18.33
2	Regardless of your group, did the study sessions, including the introduction class and repetition sessions, contribute to your learning experience?	86.66	13.33
3	Did you find using Anki flashcards helpful in learning new vocabulary words?	88.33	11.66
4	Do you think the Anki Application is more interesting than the usual way of learning vocabulary?	90	10
5	For all participants: Do you think that keywords and clues (whether AI-generated or not) can provide meaningful and helpful associations for vocabulary words and help in learning better?	73.33	26.67
6	Overall, do you feel that participating in this study positively impacted your vocabulary retention?	93.33	6.67
7	Would you recommend the use of Anki flashcards, with or without mnemonics, for vocabulary learning to your peers?	91.67	8.33
8	Do you think you can use the Anki flashcard application on your own and learn vocabulary?	86.66	13.33
9	Do you think using this application is more time-saving?	76.67	23.33

10	For the Mnemonic group: Did the AI-generated mnemonics provided along with the three Anki flashcards enhance your ability to remember and recall vocabulary words?	86.66	13.34
	For the Non-Mnemonic Group: Do you feel that the three Anki flashcards enhanced your ability to remember and recall vocabulary words without any additional cues or clues?	83.33	16.67

The survey results indicate a strong positive response to the effectiveness of Anki flashcards in vocabulary learning. A significant majority of participants, 88.33%, found using Anki flashcards helpful in learning new vocabulary words. This suggests that Anki, with its spaced repetition system, is well-received as a tool for vocabulary acquisition among the study participants. Moreover, a considerable portion, 90%, found the Anki application more interesting than the traditional way of learning vocabulary, highlighting the engaging nature of this learning method. When considering the impact of study sessions, including the introduction class and repetition sessions, on the overall learning experience, an overwhelming 86.66% of participants acknowledged a positive contribution. This indicates that the structured sessions, whether they involved mnemonics or not, played a vital role in enhancing the participants' learning experiences.

The survey also explored the participants' perception of the mnemonic approach, particularly in the Mnemonic group where AI-generated mnemonics were provided along with Anki flashcards. Results show that 86.66% of participants in the Mnemonic group felt that AI-generated mnemonics enhanced their ability to remember and recall vocabulary words. On the other hand, in the Non-Mnemonic Group, where traditional Anki flashcards without additional cues were provided, 83.33% of participants believed that these flashcards alone enhanced their ability to remember and recall vocabulary words. This suggests that both groups, whether utilizing mnemonics or not, perceived positive impacts on their vocabulary retention.

When asked about the broader applicability and recommendation of Anki flashcards, an impressive 91.67% of participants expressed willingness to recommend the use of Anki flashcards, with or without mnemonics, for vocabulary learning to their peers. This indicates a high level of confidence in the effectiveness of Anki as a learning tool. Additionally, a majority of participants, 76.67%, believed that using the Anki application is more time-saving, highlighting a practical advantage of this method in terms of efficiency. Furthermore, a significant 93.33% of participants felt that participating in the study positively impacted their vocabulary retention, emphasizing the overall success and benefits of the implemented vocabulary learning approach.

In summary, the survey results suggest a favorable view of Anki flashcards, both with and without mnemonics, in enhancing vocabulary learning among non-native English-speaking undergraduate students. The positive responses indicate the potential of these methods for effective and engaging language acquisition.

5. Discussion

This research sought to investigate the effectiveness of Anki flashcards, with and without AI-generated mnemonics, in enhancing vocabulary retention among non-native English-speaking undergraduate students. The findings from the vocabulary achievement test revealed significant improvements in both groups. The Mnemonic group, using Anki flashcards with AI-generated mnemonics, exhibited a substantial mean difference of -17.5333, indicating a statistically significant enhancement in vocabulary retention. The Non-Mnemonic group, employing traditional Anki flashcards without mnemonics, also showed a noteworthy improvement with a mean difference of -14.1333. Comparative analysis through an independent sample t-test highlighted a significant difference in vocabulary retention between the Mnemonic and Non-Mnemonic groups. The Mnemonic group outperformed the Non-Mnemonic group, signifying the positive impact of mnemonic techniques in vocabulary acquisition among intermediate-level ESL learners.

Survey results further supported the effectiveness of Anki flashcards, with 88.33% of participants finding them helpful in learning new vocabulary words. The majority, 86.66%, in the Mnemonic group believed that AI-generated mnemonics enhanced their ability to remember and recall words. In the Non-Mnemonic group, 83.33% perceived traditional Anki flashcards as effective in aiding vocabulary recall. Notably, 91.67% were willing to recommend Anki flashcards to their peers for vocabulary learning. Participants also expressed positive sentiments about the overall learning experience, with 86.66% acknowledging the positive contribution of study sessions. A significant majority, 93.33%, felt that participating in the study positively impacted their vocabulary retention.

It can be inferred that the integrated use of Anki flashcards, mnemonics, and structured study sessions proved to be a powerful strategy for enhancing vocabulary learning. The positive outcomes suggest the potential for these methods to be applied in language education settings, providing engaging and effective tools for non-native English learners. The study opens avenues for further exploration into the nuanced impact of AI-driven mnemonics and spaced repetition techniques in language acquisition beyond vocabulary, contributing to the ongoing evolution of language learning methodologies.

6. Suggestions

The completion of this research study unveils promising avenues for future exploration in the realm of language learning. One of the pivotal areas that merit further investigation pertains to the sustainability of the observed benefits. While the study effectively showcased the short-term efficacy of AI-generated mnemonics, delving into the durability of these learning gains over an extended duration stands as a critical next step. Understanding whether AI-enhanced vocabulary learning leads to enduring language retention could offer valuable insights into the long-term impact of mnemonic strategies.

Additionally, the research suggests the potential for comparative studies to enrich our understanding of AI-generated mnemonics across diverse educational settings, age groups, and linguistic contexts. Such studies could shed light on specific areas and learner demographics where AI-driven approaches excel or where customization may be necessary. By conducting comparative analyses, future research could provide tailored strategies aligned with the unique needs of different learner profiles. Expanding the role of AI in language learning emerges as another promising trajectory for future exploration. The study primarily focused on vocabulary acquisition, and investigating how AI could enhance other language skills—listening, speaking, and writing—would provide a more holistic perspective on its potential in language instruction. This expanded scope could unravel the adaptability and personalization capabilities of AI across various language learning domains, potentially revolutionizing language education strategies. Furthermore, the combination of AI-generated mnemonics with multimodal learning techniques presents a comprehensive approach to language learning. Exploring the integration of AI-generated aids with multimedia resources, such as audio and video, has the potential to create an immersive and engaging learning experience. This approach caters to diverse learning styles and preferences, offering a promising avenue to accelerate language acquisition.

The implications of this study for the future of language learning and pedagogy are noteworthy. The demonstrated effectiveness of Anki flashcards, whether with traditional features or enhanced by AI, underscores their potency as robust tools for vocabulary acquisition. The principle of spaced repetition embedded in Anki aligns seamlessly with memory psychology, contributing to enhanced long-term retention. Moreover, the study accentuates the potential of AI-generated mnemonic keywords to elevate vocabulary retention. The Mnemonic group, leveraging AI-generated mnemonics, surpassed the Non-Mnemonic group, signaling the utility of AI in providing personalized mnemonic aids. This discovery opens up possibilities for standardized and improved vocabulary learning methods that adapt dynamically to individual learner needs.

In conclusion, the future landscape of language learning could witness transformative advancements through personalized, adaptive, and comprehensive approaches, fueled by the integration of AI. The research pathways suggested herein have the potential to reshape language education, making it more efficient, engaging, and finely tuned to the diverse needs of learners.

Acknowledgements

We extend our thanks to the unidentified reviewers for their thorough assessment of the manuscript and their valuable comments, which greatly enhanced the clarity of the paper.

Authors contributions

Ms. Diana Agnes played a crucial role in the conceptualization, resource gathering, analysis, and initial drafting of the manuscript. Dr. R. Srinivasan, serving as the corresponding author and supervisor, contributed by editing, reviewing, and refining the final draft.

Funding

No funding has been received for the publication of the paper.

Competing interests

The authors declare that they have no known competing financial interests or personal relationships that have appeared to influence the work reported in this paper.

Informed consent

Obtained.

Ethics approval

The Publication Ethics Committee of the Sciedu Press.

The journal's policies adhere to the Core Practices established by the Committee on Publication Ethics (COPE).

Provenance and peer review

Not commissioned; externally double-blind peer reviewed.

Data availability statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Data sharing statement

No additional data are available.

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Appendix A

Vocabualry Acheivement Test

Vocabulary Achievement Test

Instructions:

This test consists of 50 questions, and you have 60 minutes to complete it.

Read each question carefully and select the best answer.

I. Choose the correct answer from the options given.

1. The desert has..... climate, with very little rainfall.
 - a) resilient
 - b) arid
 - c) benevolent
2. The patients in the..... were quiet and sad.
 - a) haughty
 - b) renovation
 - c) asylum
3. The..... old man donated a large sum to the charity.
 - a) benevolent
 - b) assiduous
 - c) hedonist
4. The teacher had to.....the students for destroying the teaching aids.
 - a) Censure
 - b) Reverence
 - c) Camaraderie
5. The..... journey to the hill station made them all tired.
 - a) Impetuous
 - b) Circuitous
 - c) sagacity
6. The team'sand hardwork helped them win the football match.
 - a) Resilient
 - b) Assiduous
 - c) Camaraderie
7. She has always beenwith her spending since she has debts to pay.
 - a) Asylum
 - b) Frugal
 - c) impute
8. The manager's..... attitude was disliked by many in the office.
 - a) Sagacity
 - b) Scrutinize
 - c) Haughty
9. Her decision to drop her studies made her regret it later.
 - a) Hackneyed
 - b) Impetuous
 - c) assiduous

10. The scientist developed a to explain the findings of his study.
 - a) hypothesis
 - b) Reverence
 - c) censure
11. Her uncle is famous for his.....jokes that make his presence even more annoying.
 - a) benevolent
 - b) arid
 - c) hackneyed
12. His life as amade him addicted to alcohol.
 - a) Camaraderie
 - b) Hedonist
 - c) benevolent
13. She wasblame to her sister for breaking her vase, despite having no evidence.
 - a) Resilient
 - b) Imputing
 - c) scrutinizing
14. The brothers finally decided to..... after years of treating each other as enemies.
 - a) Scrutinize
 - b) Impute
 - c) reconcile
15. The hotel underwent a..... and now it looks exquisite.
 - a) Circuitous
 - b) renovation
 - c) scrutinizing
16. Even when the footballer was criticised for his performance he was..... and never gave up.
 - a) Assiduous
 - b) Resilient
 - c) arid
17. He had a.....response, even when he heard about his mother's death.
 - a) Hedonist
 - b) reverence
 - c) nonchalant
18. The people gathered near the chapel to show their..... for the Pope.
 - a) Assiduous
 - b) Haughty
 - c) reverence
19. Hisand wisdom is what made him successful today.
 - a) Impetuous
 - b) Circuitous
 - c) sagacity
20. The evidence collected from the crime scene was thoroughly.....by the police.
 - a) Impute
 - b) Scrutinize

c) nonchalant

II. Fill in the Blanks

Complete the sentences with the appropriate vocabulary words

(tactful, compassion, tenacious inevitable, submissive, nonchalant, lobbyist, mundane, suppress, deleterious)

1. The doctor'sfor his patients is evident in the way he cares for them.
2. The situation was such that it wasfor her to avoid the travel.
3. The slaves were supposed to beto their masters before the war happened.
4. His secretary was thewho attended the meeting to discuss the bill.
5. It is always better to your anger and think wisely before speaking.
6. His overindulgence in alcohol had effects on his health.
7. His life has become so..... ever since he started working overseas.
8. He wasin convincing the clients to buy the house.
9. He was actingabout the match but was quite nervous.
10. His efforts to crack the exam secured him the scholarship.

III. Choose the right definition from the options given.

For each word, choose the best definition from the options provided.

- 1) Demagogue:
 - a) A type of wild animal.
 - b) A charismatic orator who appeals to emotions and prejudices.
 - c) A scientific instrument used for measuring temperature.
- 2) Digression:
 - a) A short journey or outing.
 - b) A departure from the main subject in speech or writing.
 - c) A strong, unpleasant odour.
- 3) Querulous:
 - a) Expressing a wish for something.
 - b) Complaining in a petulant or whining manner.
 - c) Demonstrating kindness and generosity.
- 4) Rancorous:
 - a) Friendly and congenial.
 - b) Bitter, long-lasting resentment or ill will.

- c) Brightly coloured or ornate.
- 5) Anonymous:
 - a) Well-known and recognized.
 - b) A person who is shy and reserved.
 - c) Of unknown identity or name.
- 6) Florid:
 - a) Simple and plain.
 - b) Elaborate, showy, or excessively ornate.
 - c) A type of musical instrument.
- 7) Exasperation:
 - a) A state of becoming tired or exhausted.
 - b) The feeling of intense irritation or annoyance.
 - c) A long and difficult journey.
- 8) Provocative:
 - a) A person who is easily influenced.
 - b) Tending to stimulate or provoke a reaction.
 - c) Deserving of praise and admiration.
- 9) Antagonist:
 - a) A person who opposes or competes with another.
 - b) A close friend or ally.
 - c) A type of wild animal.
- 10) Fortuitous:
 - a) Happening by chance or luck.
 - b) Careful planning and foresight.
 - c) A type of natural disaster.

IV. Make a sentence with the following words.

- | | | | |
|---------------|---------------|----------------|------------|
| 1) abbreviate | 4) enervating | 7) pretentious | |
| 2) Abdicate | 5) divergent | 8) parched | |
| 3) abstinence | 6) crater | 9) vindicate | 10) zealot |

Appendix B

Questionnaire - Students' Attitude Towards AI application

Questionnaire Survey

Please answer the following questions by putting a tick mark [✓] in the appropriate box for each question. All information collected in this questionnaire will be kept strictly confidential.

Name-

Date-

Mnemonic Group/Non-Mnemonic Group (✓ whichever is applicable)

NO	QUESTIONS	YES	NO
1	Did the flashcards aid your vocabulary learning during the study sessions?		
2	Regardless of your group, did the study sessions, including the introduction class and repetition sessions, contribute to your learning experience?		
3	Did you find using Anki flashcards helpful in learning new vocabulary words?		
4	Do you think the Anki Application is more interesting than the usual way of learning vocabulary?		
5	For all participants: Do you think that mnemonics (whether AI-generated or not) can provide meaningful and helpful associations for vocabulary words and help in learning better?		
6	Overall, do you feel that participating in this study positively impacted your vocabulary retention?		
7	Would you recommend the use of Anki flashcards, with or without mnemonics, for vocabulary learning to your peers?		
8	Do you think you can use the Anki flashcard application on your own and learn vocabulary?		
9	Do you think using this application is more time-saving?		
10	For the Mnemonic group: Did the AI-generated mnemonics provided along with the three Anki flashcards enhance your ability to remember and recall vocabulary words? For the Non-Mnemonic Group: Do you feel that the three Anki flashcards enhanced your ability to remember and recall vocabulary words without any additional cues or clues?		